3. AFFECTED ENVIRONMENT

■ PHYSICAL ENVIRONMENT

3.1 GEOLOGY

3.1.1 Physiography

The project area straddles the Continental Divide and lies within the Great Divide Basin of south-central Wyoming, a subsidiary basin of the Greater Green River Basin. Important natural landmarks in the area and their corresponding elevations are shown in **Table 3.1-1**.

Table 3.1-1. Important natural landmarks in the CD-C project area (north to south)

Landmark	Location	Elevation (feet)
Lost Creek Butte	NW ¼ Section 24, T23N:R95W	6,745
Stratton Knoll	N 1/2 Section 28, T23N:R91W	6,879
Ruby Knolls	Sections 26 and 27, T22N:R92W	7,165
Windy Hill (mesa)	Sections 1–5, 7–12, and 18, T21N:R91W	7,125
Latham Point	SW ¼ Section 32, T21N:R92W	7,235
Tipton Buttes	NE ¼ Section 27, T20N:R96W	7,094
Cow/Horse Butte	SE ¼ NE ¼ Section 5, T19N:R91W	7,170
High Point	SW ¼ SW ¼ SE ¼ Section 17, T19N:R92W	7,321
Sugarloaf	SE ¼ SW ¼ Section 5, T18N:R92W	7,088
Pine Butte	Center of NW ¼ Section 10, T17N:R92W	6,808
Baldy Butte	SW ¼ NW ¼ SW ¼ Section 12, T17N:R92W	6,920
North Flat Top	SW ¼ Section 35 T15N:R93W and NW ¼ Section 2, T14N:R93W	7,822
East Flat Top	Center of the E 1/2 Section 18, T14N:R92W	7,560

The Continental Divide splits the project area into approximately northern and southern halves and, to a greater or lesser degree, parallels the I-80 highway and utilities corridor. Along and just north of the I-80 corridor, Five Mile Ditch, Latham Draw, and Hansen Draw drain the western part of the Great Divide Basin, whereas Buck Draw and Creston Draw drain to the northeast, off Latham Mesa. Farther north and northwest, the physiography of the project area is dominated by eolian features, and most watercourses are short and drain into small to very large interior basins. North of Tipton, the topography of the Red Desert Basin, the Lost Creek Basin, Chain Lakes Flat, and Battle Springs Flat is typified by eolian flats and dry playas lying in broad topographic depressions surrounded by areas of vegetated sheet or dune sand. These larger depressions are developed between elevations of about 6,450 and 6,600 feet. Dozens of smaller, internally drained basins occur near and south of the I-80 corridor, most notably including the Wamsutter and Frewan Depressions (at about 6,600 to 6,700 feet in elevation), and basins southeast of the Creston I-80 exit (S ½ T20N:R92W and SE ¼ SW ¼ T20N:R91W). Hundreds of smaller, internally drained basins occur throughout the project area, especially in places in which the surface rock or soil has been covered by dunes or a veneer of windblown sand.

In the eastern part of the project area, Fillmore Creek is a primary drainage north of the Continental Divide. Its principal tributaries include Coal Gulch, Coal Bank Wash, and Badwater Creek. Muddy Creek—tributary to the Little Snake River—is the dominant drainage south of the Divide. Its tributaries include Holler Draw, Chicken Springs Creek, and Soap Hole Wash that flow south off the Continental

Divide, supplemented by the south-flowing Barrel Springs Draw and Antelope Creek, and the east-flowing Windmill Draw, Red Wash, Blue Gap Draw, Robbers Gulch, Little Robbers Gulch, and the North Fork of Cottonwood Creek. Surface elevations within the project area range from a high of 7,822 feet on North Flat Top in the NW ¼ Section 2, T14N:R93W, to a low of 6,340 feet in the lower drainage of Muddy Creek in Section 32, T14N:R91W, making project area relief about 1,482 feet. The slope of the land along the floodplain of Muddy Creek within and marginal to the project area is a gentle 400 feet in 26.2 miles, or about 0.29 percent. Limited areas of exposed rock forming rugged badland hills border the Muddy Creek valley to the east and west, and some of these badland hills exhibit slopes of up to 13.7 percent for short distances. The region of greatest physical relief in the study area—along North Flat Top in Section 35, T15N:R93W—has a slope of 18.9 percent, or about a 1,000-foot rise in elevation per mile. The majority of the project area, however, shows gentler slopes of 1.7 to 4.2 percent (about 90–220 feet/mile).

The project area is dominated by semiarid desert that receives an average of 7.1 inches of annual precipitation, ranging from 3.8 inches to 13.6 inches. The annual temperature ranges from -30 ºF in winter to more than 100 ºF in summer. Sagebrush (*Artemisia* sp.) is the dominant vegetation and grows in patches and thickets. Along the larger drainages sagebrush is supplemented by bunch grasses, cheatgrass, greasewood, rabbitbrush, lichens, cottonwood, and a variety of other plants (Roehler 1993). Vegetation is wholly absent in several areas of badlands, and gullying can be severe in areas of headward erosion derived from badland areas, in places where the overlying sediment has been disturbed, or on poorly vegetated slopes greater than 2 percent. Much of the lower reach of Muddy Creek is entrenched in a floodplain gully system up to 20 feet in depth.

3.1.2 Regional Geologic Overview

The project area lies within the southern and eastern parts of the Great Divide and Washakie structural basins, sub-basin regions of the Greater Green River Basin of southernmost central Wyoming. Structurally, rocks in the area dip in a curving fashion to the west, southwest, and south of the structural high of the Sierra Madre Range, and to the south off the Wamsutter Arch, into the Washakie structural basin.

The west flank of the Sierra Madre is bounded by a major eastward-dipping reverse fault system, along which it was elevated over the eastern edge of the Greater Green River Basin (including the Washakie Basin) during the Laramide Orogeny of the late Cretaceous to early Tertiary period. These reverse faults are not exposed at the surface, but rather lie buried beneath early Tertiary sediments that fill the basin. The Washakie and Greater Green River basins to the west, into which the surface rocks dip, are bounded by east-west oriented structural highs, the Wamsutter Arch to the north and Cherokee Ridge to the south, respectively. The structural axis of Cherokee Ridge trends along the Wyoming/Colorado state line and separates the extreme southeastern arm of the Greater Green River Basin of Wyoming from the Sand Wash Basin of Colorado. Numerous faults occur along Cherokee Ridge, many of which show evidence of recurrent motion throughout the last 20 million years. None of these, however, show indication of Quaternary movement (Case *et al*. 1994).

Geologic mapping by the U.S. Geological Survey (USGS) and Wyoming Geologic Survey (Weitz and Love 1952, Love 1970, Love and Christiansen 1985, Love *et al*. 1993, Roehler 1973, 1977, 1985; Honey and Hettinger, 2004; Hettinger and Honey, 2005) documents that the project area has surface sedimentary exposures of Quaternary, Tertiary, and Late Cretaceous age. These deposits are in turn underlain in the subsurface by Phanerozoic-age sedimentary rocks of Cretaceous to Cambrian age, which are in turn underlain by Precambrian metamorphic bedrock that comprises part of the ancient North American craton (continental core) and exceeds two billion years in age.

Information on geologic units preserved at the surface and in the subsurface within the project area is provided in **Table 3.1-2**; a generalized stratigraphic column of these rocks is provided in **Figure 3.1-1.** A diagram showing the complex stratigraphic relations of Eocene deposits is provided in **Figure 3.1-2**.

Table 3.1-2. Surface and subsurface geologic deposits in the CD-C project area

Geologic Deposit	Geologic Age	Environment/Lithology	Resources (PFYC=Probable fossil yield class)
Surface Deposits			
Unnamed Quaternary deposits	Holocene-Pleistocene	Eolian/fluvial/colluvial/ landslide. Sand, gravel, clays, weathered-in-place residuum from exposed outcrops	None reported within area, economic deposits of wind-blown sand reported 20–30 miles NNE of the town of Baggs, Wyoming, just east of the project area
Green River Formation • Laney Shale • Godiva Rim Member • Wilkins Peak Member • Tipton Tongue • Luman Tongue	Early – Middle Eocene	Lacustrine: near shore line/saline flats. Oil shale, carbonaceous shale, calcareous shale sandstone, mudstone, limestone, marlstone, oolitic and pisolitic limestone, stromatolites, trona, halite	Vertebrate (including abundant fish and flamingo), invertebrate and plant fossils (BLM PFYC 5 for Formation). Oil shale, Halite and trona east of Rock Springs.
Battle Spring Formation	Paleocene to early Eocene	Terrestrial/alluvial fan/fluvial. Arkosic (feldspar-rich) sandstone	Possible vertebrate fossils, but correlation uncertain (BLM PFYC 2-3); Gravel and uranium in Great Divide Basin
Wasatch Formation • Cathedral Bluffs Tongue • Main Body • Niland Tongue • Ramsey Ranch Member	Early Eocene	Terrestrial: fluvial/flood plain/swamp, drab to varicolored mudstone, sandstone, carbonaceous shale and coal	Vertebrate, invertebrate, and plant fossils (BLM PFYC 5); coal; petroleum in Table Rock fields; uranium reported in adjacent areas near Wamsutter, Creston, and Latham
Fort Union Formation	Paleocene	Terrestrial: fluvial/flood plain/swamp, chiefly somber-colored sandstones, mudstones, carbonaceous shales and coals	Vertebrate, invertebrate, and plant fossils (BLM PFYC 3); petroleum in Table Rock and Wild Rose fields; coal, coalbed methane
Lance Formation	Late Cretaceous	Terrestrial: fluvial/ floodplain/swamp, brown and gray sandstone, shale and mudstone, coals, and carbonaceous shales	Vertebrate, invertebrate and plant fossil (BLM PFYC 5); coal; coalbed methane, petroleum in Barrel Springs, Blue Gap, Bush Lake, Emigrant Trail, Great Divide, Hay Reservoir, Robbers Gulch, Wamsutter, and Wild Rose fields
Subsurface Deposits			
Fox Hills Sandstone	Late Cretaceous	Near-shore and marginal marine gray shale and interbedded grayish-orange sandstone	Petroleum in Table Rock Field, other production may be included with Lance Formation; potential petroleum reservoir rock

Source: Geologic mapping by the U.S. Geological Survey (USGS) and Wyoming Geologic Survey (Weitz and Love 1952, Love 1970, Love and Christiansen 1985, Love et al 1993, Roehler 1973, 1977, 1985; Honey and Hettinger, 2004; Hettinger and Honey, 2005.

Table 3.1-2. Surface and subsurface geologic deposits in the CD-C project area, *continued*

Geologic Deposit		Geologic Age	Environment/Lithology	Resources (PFYC=Probable fossil yield class)
Lewis Shale		Late Cretaceous	Marine shale and sandstone	Petroleum in Baldy Butte, Barrel Springs, Bastard Butte, Battle Springs, Blue Gap, Bush Lake, Coal Gulch, Continental Divide, Cow Creek, Creston, Delaney Rim Unit, Echo Springs, Emigrant Trail, Fillmore, Frewen, Gale, Great Divide, Hay Reservoir, Lost Creek Basin, Lost Creek, Nickey, Red Desert, Robbers Gulch, Salazar, Sentinel Ridge, Siberia Ridge, Standard Draw, Stock Pond, Strike, Table Rock, Table Rock SW, Tierney, Wamsutter, and Wild Rose fields
Mesaverde Group	Almond Formation	Late Cretaceous	Marine, terrestrial, deltaic: white and brown sandstone, sandy shale, coal, carbonaceous shale	Petroleum in Baldy Butte, Barrel Springs, Battle Springs, Blue Gap, Bush Lake, Coal Gulch, Creston, Creston Southeast, Delaney Rim Unit, Echo Springs, Emigrant Trail, Fillmore, Five Mile Gulch, Frewen, Hay Reservoir, Monument Lake, Nickey, Red Desert, Robbers Gulch, Sentinel Ridge, Shell Creek, Siberia Ridge, Standard Draw, Stock Pond, Strike, Table Rock, Table Rock SW, Tierney, Wamsutter, Wells Bluff, and Wild Rose, Windmill Draw fields; coal; coalbed methane
	Ericson Sandstone (a/k/a Pine Ridge or Williams Fork Formation)	Late Cretaceous	Marine: coastal plain, estuary/beach, white sandstone, lenticular conglomerate, coal	Petroleum in Battle Springs, Continental Divide, Creston, Echo Springs, Fillmore, Five Mile Gulch, Gale, Lost Creek Basin, Monument Lake, Sentinel Ridge, Siberia Ridge, Standard Draw, Stock Pond, Strike, Table Rock, Wamsutter, Wells Bluff, Wild Rose, and Windmill Draw Fields
	Rock Springs (a/k/a Allen Ridge or Iles) Formation	Late Cretaceous	Terrestrial, coastal plain white to brown sandstone, shale, mudstone, coal	Petroleum in Wamsutter Field; other production may be included in Mesaverde (undivided); potential petroleum reservoir rock
	Blair (=Haystack Mountains) Formation	Late Cretaceous	Marine	Petroleum in Creston and Table Rock Field; other production may be included in Mesaverde (undivided)
Steele Shale (includes Shannon, Sussex Sandstones)		Late Cretaceous	Marine: gray shale, with numerous bentonites, sandstone	None reported, potential petroleum source and reservoir rock
Niobrara Formation		Late Cretaceous	Marine: light-colored limestone, gray limey shale	None reported, potential petroleum source and reservoir rock
Frontier Formation		Late Cretaceous	Marine: deltaic, gray sandstone and sandy shale	Petroleum in Cow Creek and Table Rock fields; potential petroleum source and reservoir rock

Table 3.1-2. Surface and subsurface geologic deposits in the CD-C project area, *continued*

Geologic Deposit	**Geologic Age**	**Environment/Lithology**	**Resources (PFYC=Probable fossil yield class)**
Mowry Shale	Late Cretaceous	Marine: silver-gray, hard siliceous shale, with abundant fish scales and bentonites	None reported, potential petroleum source rock
Muddy Sandstone	Early Cretaceous	Marine: deltaic, gray to brown sandstone, conglomeratic	Petroleum in Cow Creek Field; potential petroleum reservoir rock
Thermopolis Shale	Early Cretaceous	Marine, black, soft, fissile shale	None reported, potential petroleum source rock
Cloverly Formation (=Dakota & Lakota Sandstones)	Early Cretaceous	Terrestrial, variegated mudstone, bentonitic, conglomeratic sandstone	Petroleum in Cow Creek Field; potential petroleum reservoir rock
Geologic Deposit	Geologic Age	Environment/Lithology	Resources (PFYC=Probable fossil yield class)
Morrison Formation	Jurassic	Terrestrial, varicolored mudstones, white sandstone, bentonite	None reported; potential petroleum reservoir rock
Sundance Formation	Jurassic	Marine, green-gray glauconitic sandstone and shale, underlain by red and gray non-glauconitic shale and sandstone	None reported; potential petroleum reservoir rock
Nugget Sandstone	Triassic to Jurassic	Eolian, gray to red, massive to cross-bedded sandstone	Petroleum in Cow Creek and Table Rock fields; potential petroleum reservoir rock
Chugwater Formation	Triassic	Terrestrial/mud flat, red shale and siltstone, sandstone	Potential petroleum reservoir rock
Goose Egg Formation	Permian to Triassic	Marine, gray to olive dolomitic siltstone; red sandstone and siltstone, gypsum, halite, purple to white dolomite and limestone	None reported
Tensleep Sandstone	Pennsylvanian	Marine, white to gray sandstone with limestone and dolomite	Potential reservoir rock.
Amsden Formation	Mississippian to Pennsylvanian	Marine, red and green shale and dolomite, persistent red to brown sandstone at base	None reported
Madison Limestone	Mississippian	Marine, blue-gray massive limestone and dolomite	Petroleum in Table Rock Field
Flathead Sandstone	Cambrian	Marine/shoreline, red, banded, quartzose sandstone	None reported
Unnamed metamorphic rocks	Precambrian	Igneous/metamorphic, granitic and/or intrusive	None in area but Sierra Madre contain ores of uranium, copper, silver, lead, zinc, gold, and barium; and industrial (building and decorative) grades of quartzite, marble, and granite

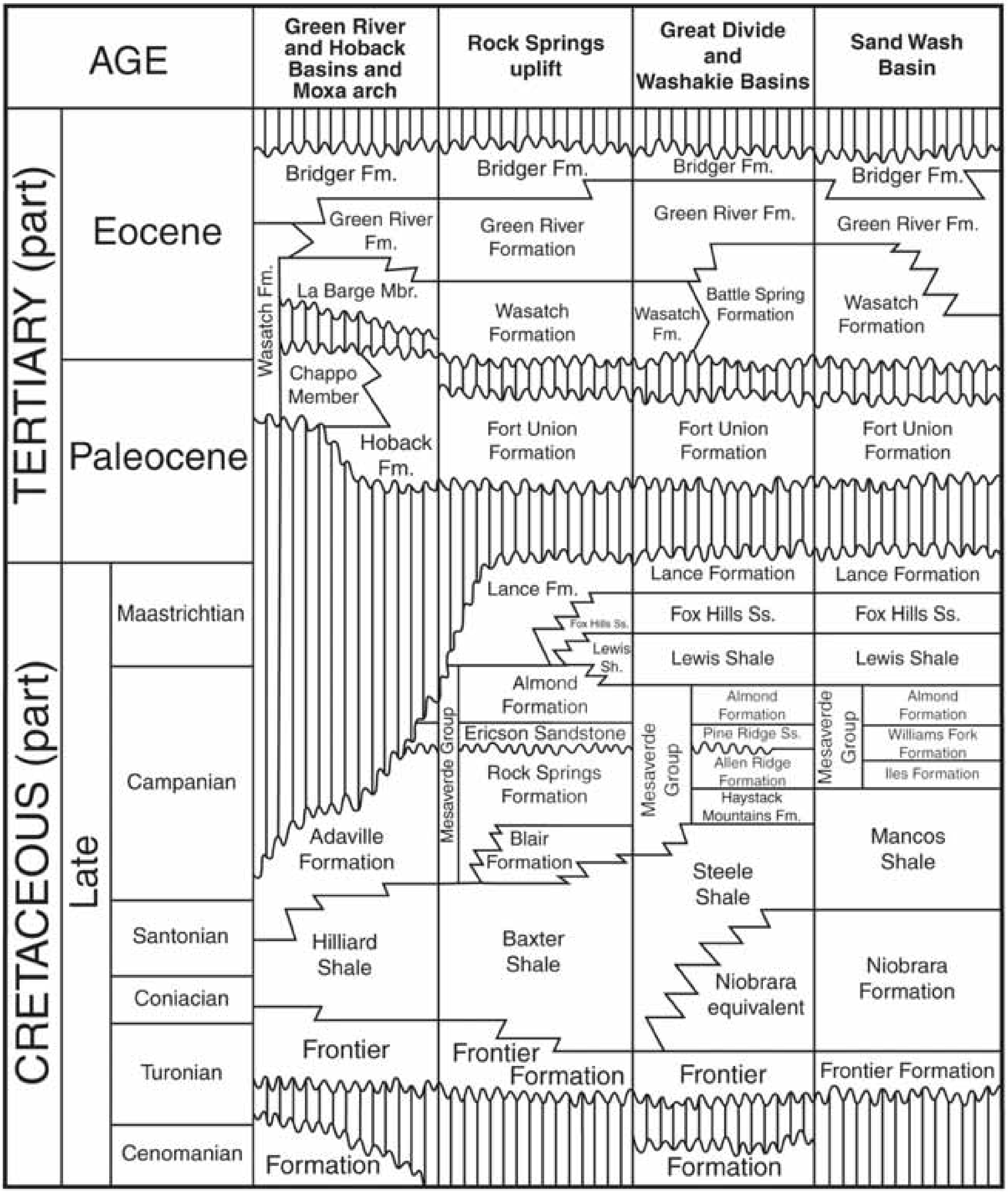


Figure 3.1-1. Generalized stratigraphic column

The Battle Spring Formation (not shown in this chart) is a coarse-grained deposit that accumulated along the southern flank of the Granite Mountains. It is equivalent to the Wasatch and Green River Formations and possibly part of the Fort Union Formation.

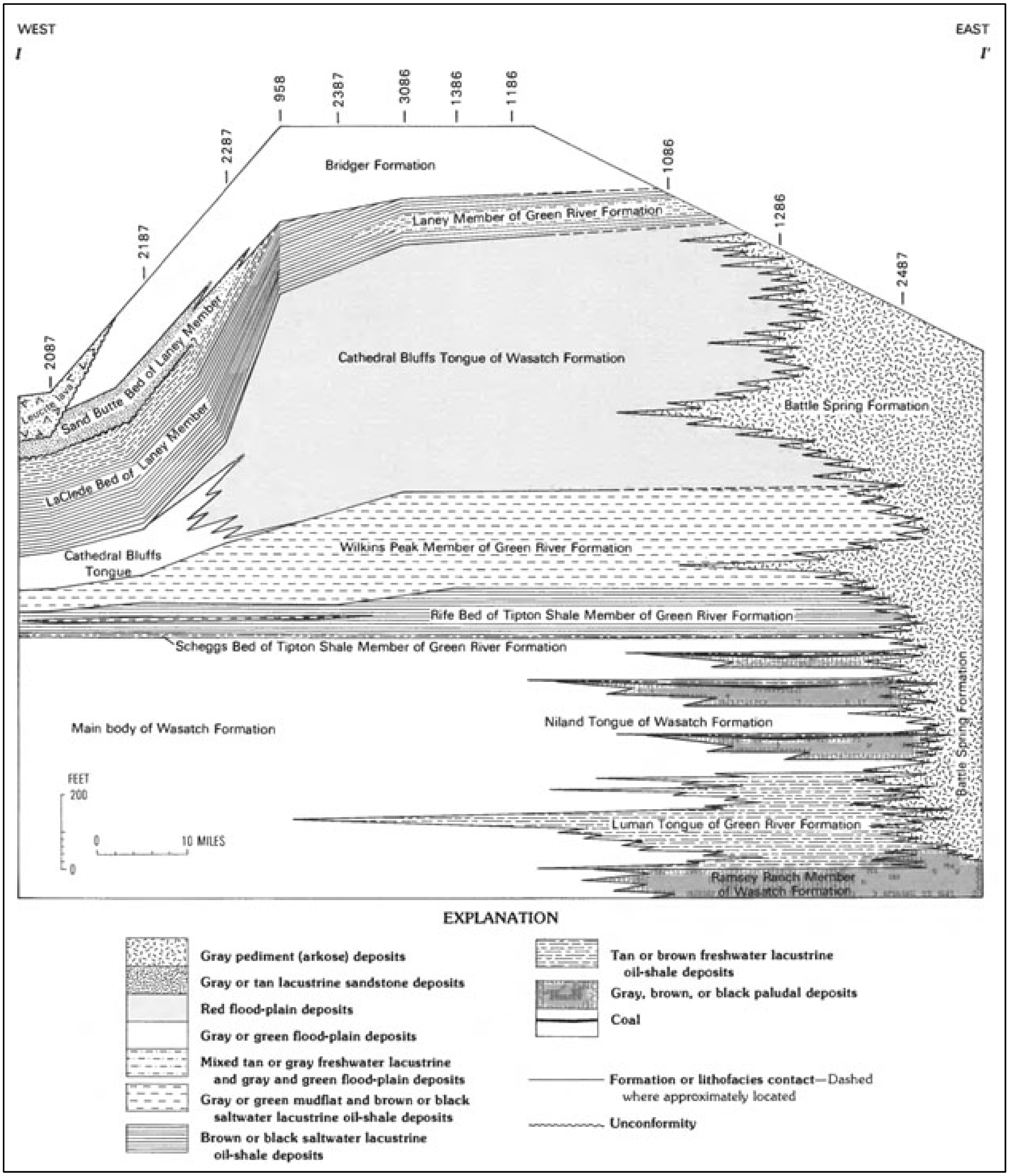


Figure 3.1-2. Eocene stratigraphic units, Greater Green River Basin

Source: Modified from Roehler (1989)

Rock terminology for the Cretaceous (Mesaverde Group, a subsurface unit in the project area) is complicated in that scientific studies of these rocks reference a number of different formations within the project area. Although the Wyoming Chart of Stratigraphic Nomenclature lists the Almond, Ericson, Rock Springs, and Blair formations within the Mesaverde Group in the Washakie Basin, alternative terminology has been used for these same rocks by authors describing the coals of the Mesaverde. Rock equivalent names for the Ericson Sandstone include the Williams Fork Formation or Pine Ridge Sandstone; for the Rock Springs Formation, the Allen Ridge Sandstone or Iles Formations; and for the Blair Formation, the Haystack Mountain Formation.

Additional details on surface deposits are provided in **Section 3.1.3**. Petroleum production targets are generally in the Mesaverde Group (undivided) in the following fields: Baldy Butte, Barrel Springs, Bastard Butte, Battle Springs, Blue Gap, Coal Gulch, Continental Divide, Cow Creek, Creston, Delaney Rim Unit, Echo Springs, Emigrant Trail, Fillmore, Five Mile Gulch, Frewen, Hay Reservoir, Lost Creek Basin, Monument Lake, Red, Red Desert, Robbers Gulch, Salazar, Sentinel Ridge, Shell Creek, Siberia Ridge, Stock Pond, Strike, Table Rock, Tierney, Wamsutter, Wells Bluff, Wild Rose, and Windmill Draw.

3.1.3 Quaternary Deposits

Quaternary deposits in the project area include widespread deposits of alluvium, colluvium, and slope wash; eolian sand dunes; and residuum developed on formations of Cretaceous (Lance Formation), Paleocene (Fort Union Formation), and Eocene (Battle Spring, Green River, and Wasatch Formations) ages.

Extensive deposits of windblown sand blanket bedrock exposures of Tertiary rocks in T15-17N:R93W, with more isolated deposits occurring in T15N:R92W (Love and Christiansen 1985). These deposits range in thickness up to about 30 feet, and the sediment has been partly stabilized by vegetation, dampness, and weak cementation in some areas. Relatively pure, naturally size-sorted eolian sand is an economic resource, and sand-quarry pits have been developed in Section 9, T15N:R92W and just to the southeast of that area, outside the project boundaries (Harris 1996). The northern part of the project area is dominated by eolian deposits and an eolian-created topography. The Red Desert, Lost Lake, and String Lake Basins are deflated playas surrounded by loess deposits.

Deposits of alluvium, at least up to 30 feet thick, are developed in the bed and floodplain of Muddy Creek in the central and southeast parts of the project area, and much thinner alluvial accumulations occur in the beds of tributary streams near where they join Muddy Creek. The alluvium consists for the most part of medium to fine sand, mud, and mudstone rip-up clasts, all derived from the surrounding badland hills. Chert pebbles, sandstone clasts, and weathered Eocene soil (paleosol) nodules commonly occur as part of streambed loads. Pebble to cobble-sized gravel forms some of the ancient terrace sediment above Muddy Creek on its east side, and these deposits are exploited locally as road metal or in making concrete filler (for example, in the SW ¼ SE ¼ Section 21, T18N:R91W). The site of the lauded “Rawlins Mammoth,” discovered in 1961, is located near Chicken Springs in the NW ¼ SW ¼ SE ¼ Section 1, T18N:R91W.

Drapes of colluvial sediment, consisting mainly of mud with a lesser amount of fine sand and lag accumulations of Eocene soil nodules, border nearly all the badland hills and are derived from them.

Terrace gravel and gravel deposits of Holocene and perhaps Pleistocene age occur sporadically throughout the area along the former course of Muddy Creek and at higher elevations. Older high-level terrace gravels suggest that Muddy Creek and its subsidiary tributaries drained northward into the Great Divide Basin in the past and that its present southward drainage into the Little Snake River was the result of stream piracy.

3.1.4 Tertiary—Battle Spring Formation

The Battle Spring Formation (Pipiringos 1961) is a fluvial deposit of middle Eocene age that forms a foundation for most of the buttes and mesas bordering the playas in the project area north of the Continental Divide. The unit consists of gray, orange, and red mudstones, volcanic mudstones, carbonaceous mudstones, orange and brown sandstones, and stringers of gravel conglomerate, and it is especially well exposed in the area of Ruby Knolls and on the east side of Frewan Mesa. The Battle Spring Formation has yielded a small fauna of fossil vertebrates, including the fragmentary bone of a crane or a large, flightless bird discovered during reconnaissance fieldwork for this project.

3.1.5 Tertiary—Green River Formation

Within the project area, the Eocene Green River Formation (chiefly of middle Eocene age) is restricted to the area around the I-80 corridor (between Wamsutter and Tipton Buttes) and to the extreme southwest, where it makes up the upper part of the escarpment forming Flat Top Mountain. From oldest to youngest, the Green River consists of the Luman Tongue, the Tipton Tongue, Wilkins Peak Member (lower part only), Godiva Rim Member, and the Laney Member. Sediments comprising the Green River Formation accumulated in environments in and adjacent to Lake Gosiute (and its predecessor Lake Luman) in response to the rise and fall in lake level during the Early Eocene. Environments of deposition included fluvial, paludal, freshwater lacustrine, saltwater lacustrine, pond and playa lake, evaporate pans, mudflat, and volcanic and fluviovolcanic (Roehler 1993).

The Luman Tongue forms the base of the Green River Formation on the southern edge of the Great Divide Basin. The tongue is composed chiefly of organic-rich oil shales, carbonaceous shales, limestones, sandstones, and mudstones that accumulated in Lake Luman above deposits of the Ramsey Ranch Member of the Wasatch Formation (**Section 3.1.6**). The Luman deposits interfinger laterally to the north and south with varicolored (chiefly red) floodplain deposits of the Wasatch Formation. At its maximum extent, Lake Luman occupied an area of about 6,650 square miles.

The Tipton Tongue (including the Scheggs and Rife beds) of the Green River Formation conformably overlies the Niland Tongue of the Wasatch Formation, and is composed chiefly of marlstone, calcareous shale, and oil shale. The Scheggs Bed is predominantly oil shale and lesser algal limestones, sands, and muds that accumulated in lake and lake-shore environments during the first major expansion of ancient Lake Gosiute. Deep-lake oil shale in the Scheggs Bed preserves abundant fossils of ostracods and shallow-water lake sediments containing abundant stromatolites, the remains of calcareous algal reefs. The stromatolites exhibit a wide variety of bizarre forms that are related to ecological conditions such as water depth, temperature, salinity, and sedimentation rate, as well as other factors. The Rife Bed forms the top of the Tipton and consists chiefly of organic-rich oil shale, interbedded with a lesser amount of algal limestone, dolomite, sandstone, and mudstone. The oil shale of the Rife accumulated in the deepest parts of the lake during a 500,000-year period when Lake Gosiute dwindled to about half its former size (about 7,500 square miles) during deposition of the Scheggs Bed. The salinity of the lake must have increased dramatically as evidenced by thin layers of saline minerals such as nahcolite and disseminated crystals of shortite that occur in the upper part of the bed. Algal limestone and sands accumulated in shallower and shoreline areas.

The Wilkins Peak Member consists of many layers of cyclic sediments that include, in ascending order: oil shale, trona, halite, and mudstone that accumulated in Lake Gosiute. Only the lower part of the member is present in the project area. This part of the member consists chiefly of shales, sandstones, and trona and halite that accumulated in brackish Lake Gosiute as the lake shrank in size. The Godiva Rim Member consists chiefly of gray-brown kerogenous shale, ostracode-bearing sandstone, siltstone, and limestone that overlie and interfinger with the Cathedral Bluffs Member of the Wasatch Formation and is overlain and interfingers with the LaClede Bed of the Laney Shale.

The Laney Shale (including the LaClede and Hartt Cabin beds) forms the top of the Green River Formation and records in its sediments the greatest expansion of ancient Lake Gosiute followed by its final contraction and desiccation. At its peak the lake in which the Laney accumulated occupied more than 75 percent of the Greater Green River Basin, or about 15,000 square miles (Bucheim 1981,1986, Bucheim *et al.* 1977).The Laney Shale (including the LaClede and Hartt Cabin Beds) conformably overlies and interfingers with the Cathedral Bluffs Tongue of the Wasatch Formation, and is dominated by calcareous shale, oil shale, and shaley marlstone.

In the Piceance Basin of Colorado, the Green River Formation contains massive amounts of economically important oil shale, and elsewhere the formation is also known to yield economically important deposits of trona and gilsonite. The Green River is well known for its locally abundant remains of well-preserved fossil fish and much rarer specimens of other fossil vertebrates.

3.1.6 Tertiary—Wasatch Formation

The lower Eocene Wasatch Formation is the most extensively exposed geologic unit in the project area, with a distribution exceeding that of any other rock unit. Bedrock exposures of the Wasatch Formation, however, are generally limited to the steep, east-facing escarpments bordering much of the west side of Muddy Creek, especially beneath Flat Top Mountain, along “The Bluffs” north of Baggs, and in west-dipping cuestas north and south of the townsite of Dad. Other exposures are locally developed along and marginal to deeply incised streams on south Mexican Flats.

Within the project area, the Wasatch Formation is divided into the Main Body, Ramsey Ranch Member, Niland Tongue, and the Cathedral Bluffs Tongue. Regionally, the Main Body of the Wasatch Formation consists of up to 2,130 feet of variegated mudstone and sandy mudstone, gray sandstone, carbonaceous shale, and coal (Bradley 1964; Sullivan 1980; Roehler 1985) that were deposited in alluvial channels and back swamps, and on floodplains. Toward the basin center, the Main Body of the Wasatch conformably overlies the Paleocene Fort Union Formation, but farther east it overlaps the Fort Union and lies with angular unconformity on both the Fort Union Formation and the Upper Cretaceous Lance Formation. The floodplain deposits of the Main Body have two distinct color patterns. Around the basin edges the floodplain deposits range from red to varicolored, with some shade of red dominating. In the central parts of basin these red floodplain deposits are replaced laterally by green to gray floodplain deposits. Green to gray coloration appears to have been the result of accumulation of sediments in areas that were permanently water saturated, where iron compounds were reduced. In addition to floodplain deposits the main body of the Wasatch Formation includes some freshwater limestones that accumulated in ponds and marshes in low-lying areas and some coarse-grained sands and conglomerates that accumulated along the basin margin in alluvial fan environments. Deposits of the Main Body accumulated contemporaneously with deposits of the Ramsey Ranch Member of the Wasatch Formation and Luman and Tipton tongues of the Green River Formation.

The Ramsey Ranch Member consists of carbonaceous shale, coal, limestone, gray and green or red variegated sandstone and mudstones that accumulated in swamps, shallow lakes and ponds, and floodplains and rivers during the early stages of the development of Lake Gosiute. The member contains important deposits of oil shale, uranium, and coal.

The Niland Tongue of the Wasatch Formation consists of brown sandstone, drab mudstone, and carbonaceous shale that conformably overlie the Luman Tongue of the Green River Formation. The Niland Tongue has the same aerial distribution as the Luman Tongue of the Green River Formation. Where the Luman Tongue is absent the name Niland Tongue is discarded and those rocks are not separated from the underlying main body of the Wasatch.

The Cathedral Bluffs Tongue forms the uppermost rocks of the Wasatch Formation, overlying the Tipton Shale of the Green River Formation, and closely resembles those of the Main Body in the dominance of variegated mudstone and gray sandstone.

Economically important uranium deposits occur in coals of the Main Body and Ramsey Ranch Member of the Wasatch Formation north of Wamsutter, just west of the project area (Masursky 1962), and in the region around Creston and Latham (Harris *et al.* 1985; Harris and King 1993). Uranium is also known in arkoses of the Battle Springs Formation of the central Great Divide Basin (Pipiringos 1961), a unit approximately equivalent to the Cathedral Bluffs Tongue of the Wasatch within the report area.

Fossil vertebrates are locally abundant in the Wasatch Formation, including all the subunits that comprise the formation in the CD-C project area. Fossils are most abundant where they have weathered from immature through mature paleosols. However, about 10 miles north of Baggs, Wyoming, sandstones of the Cathedral Bluff Member that interfingers with the Tipton Shale have produced fossils of 11 mammalian species including primates, condylarths, tillodonts, dinocerates, and perissodactyls (Roehler 1988) as well as the fossils of mollusks, ostracodes, burrows, worm trails, and an unidentified tubular impression. The mollusks include very abundant shells of the gastropods *Goniabasis* and *Viviparus* as well as freshwater unionid bivalves.

The most important Wasatch Formation fossil vertebrate locality within the study area is the so-called "Dad Local Fauna" (Gazin 1962), which was collected from the east-facing exposures of the Main Body of the formation developed on bluffs north and south of the townsite of Dad. The University of Wyoming Geological Museum has 11 fossil vertebrate sites in the Wasatch Formation within the project area.

3.1.7 Tertiary—Fort Union Formation

Within the project area, the Paleocene Fort Union Formation is developed in a curved, westerly dipping outcrop. Regionally, the unit lies with erosional or angular unconformity atop the Upper Cretaceous Lance Formation (Roehler 1993). The best Fort Union exposures occur in the northeast part of the area, in Section 23, T18N:R92W; however, good but smaller and less-continuous Fort Union exposures occur beneath Wasatch-capped buttes developed just east of Muddy Creek, between the townsites of Dad and Baggs, Wyoming.

Regionally, the Fort Union Formation consists of up to 3,400 feet of drab mudstone, sandy mudstone, sandstone, carbonaceous shales, and coal. These rocks were deposited in alluvial channels and flood-basin backswamps (Sanders 1975), and up to 1,500 feet of Fort Union rocks are exposed in the Riner area, between Red Rim and Creston Junction (Sanders 1974).

Honey and Hettinger (2004) and Hettinger and Honey (2005) have mapped three members of the Fort Union Formation in the Blue Gap and Peach Orchard 7.5-minute quadrangles. These include, from youngest to oldest, the Overland, Blue Gap, and China Butte Members. The China Butte Member includes many mapped coalbeds included in five coal-bearing zones. These include the Fillmore Ranch, upper and lower Muddy Creek, Olsen Draw, and Red Rim coal zones.

The Fort Union Formation in the project area, as well as in all of south-central Wyoming, constitutes an enormous, largely untapped reserve of coal. Unfortunately, most of this resource occurs in thin and/or discontinuous beds (Smith *et al.* 1972; Sanders 1974, 1975; Beaumont 1979; Edson 1979; Hettinger and Brown 1979; Honey and Roberts 1989; Honey and Hettinger 1989a; Honey 1990; Jones 1991; Hettinger *et al.* 1991; Hettinger and Kirchbaum 1991) that are exceedingly difficult to mine economically. Sanders (1974, 1975) reports thin and discontinuous Fort Union coalbeds that thicken up to 9.8 feet in places, and units 5–25 feet thick are developed in the upper 600–700 feet of the formation just northeast of the project area. Edson (1979), Honey and Hettinger (1989a), Honey and Roberts (1989), and Honey (1990) named and/or numbered Fort Union coalbeds within and north and west of the project area, and provided subsurface correlations of coal-bearing units. Honey and Roberts (1989) recorded up to 75 feet of total coal thickness in the lower part of the Fort Union Formation in the Baggs area, and Honey and Hettinger (1989b) documented individual coalbeds up to 27.7 feet thick in the Fillmore Ranch Coal Zone (Edson 1979), within the project area.

The most recent coal-mining activity within the project area is in the Fort Union Formation at Cherokee Mine Number 1, in the SW ¼ SW ¼ NE ¼ Section 2, T19N:R92W, about 6 miles south of Creston Junction. Coal mining is also planned for the Creston Area (in T19N:R92W), and at the Chris Butte Mine Project area along the Continental Divide in Section 15, T18N:R91W.

Fossil vertebrates are well known from the China Butte Member of the Fort Union Formation within the study area, the most noteworthy locality being Swain Quarry, in the NE ¼ Section 3, T15N:R92W (Rigby 1980). Apart from Swain Quarry, the UW Geological Museum has one locality in the project area—Fort Union rocks—and an additional 13 Fort Union sites have been developed in recent years by M.C. McKenna and J.G. Honey.

The contact of the Fort Union Formation with the underlying Upper Cretaceous Lance Formation is everywhere marked by a pronounced angular unconformity and generally a thick-channel sandstone (Roehler 1993). It is unknown if the Tertiary-Cretaceous boundary is preserved in the area, but earliest Paleocene (Puercan age) rocks certainly are (see **Section 3.3 Soils**).

3.1.8 Upper Cretaceous—Lance Formation

Few exposures of Lance rocks extend into the project area, and the Lance Formation/Fort Union Formation contact in part forms the project area's eastern boundary over a short distance. However, patches of Lance are exposed in a few areas, notably in the SE ¼ Sections 13, 23, and 34, T17N:R92W, and in the E ½ Section 4, T16N:R92W.

The Lance Formation is a largely alluvial deposit made up of about 2,890 feet of interbedded gray sandstone and sandy mudstone, carbonaceous shale, and coal (Hettinger *et al.* 1991; Hettinger and Kirschbaum 1991). Honey and Hettinger (2004) and Hettinger and Honey (2005) recognize two subunits of the Lance Formation in the Blue Gap and Peach Orchard 7.5-minute Quadrangles. These include an upper Red Rim Member and an underlying unnamed member. The Red Rim Member is chiefly conglomeratic sandstone. The underlying unnamed member contains several coal units. The thickest of these, which is about six feet thick, occurs about 25 to 45 feet above the base of the formation.

Regionally, the Lance overlies the Fox Hills Sandstone (Smith 1961, Gill *et al*. 1970, Hettinger *et al*. 1991, Roehler 1993), which is included in the Lewis Shale on many maps. To the east the Fox Hills may be absent, and the Lance directly overlies the Lewis Shale (Weitz and Love 1952, Love and Christiansen 1985). Further eastward, Lance rocks correlate with the Medicine Bow Formation (Merewether 1971) and farther west, the Lance thins to less than 197 feet on the west side of the Washakie Basin (Roehler 1985).

The Lance Formation is well-known for its dinosaur remains and, within the project area, Lance rocks have yielded sparse remains of fish, crocodilians, and mammals (J.G. Honey, personal communication).

3.1.9 Geologic Hazards

Of known naturally occurring geologic hazards, fault-generated earthquakes, floods, landslides, or other mass movement, the most likely to affect the project area are mass movements that could be initiated on steep slopes. Flooding may be a hazard adjacent to steeply dipping rock outcroppings where high runoff may be expected; however, there are few such areas within the project boundaries.

There are no known faults with evidence of Quaternary movement mapped within the project area (NEIC 2003, WGS 2003); however, a number of unmapped faults are known to exist in the Washakie Basin area in southern Sweetwater and Carbon Counties. Further field investigation is necessary to determine if any of these faults should be deemed active (USGS 2012a).

Only one earthquake has been recorded within the project area. The earthquake, with a 4.3 Richter magnitude occurred April 4, 1999 and its epicenter was located near Baldy Butte in T17N:R92W (41.45˚N:107.74˚W). It was felt in Rawlins, Sinclair, Baggs, Wamsutter, and Rock Springs. Residents of Rawlins reported that pictures fell off walls. The most noteworthy damage occurred between Baggs and

Creston Junction, and at Wamsutter (USGS 2012a). The owner of a ranch house located approximately 30 miles north of Baggs reported that cinder-block walls in the basement of the home cracked, separated, and may have required replacement. A motel and associated residence in Wamsutter also suffered cracks in the cinder-block walls of the basement. No other earthquake epicenters have been recorded in or immediately adjacent to the area in the past 100 years, indicating that earthquakes are probably an unusual event and that the area may not be very seismically active (USGS 2012a).

Carbon County is primarily in Seismic Zone 1 of the Uniform Building Code. Effective peak accelerations (90 percent chance of non-exceedance in 50 years) in this zone can range from 5%g–10%g, where g = the gravitational acceleration constant (see Glossary). New probabilistic acceleration maps for Wyoming are available from the USGS (USGS 2012a). These maps assume accelerations based on what would be expected if firm soil or rock were present at the surface.

Ground accelerations shown on the USGS maps in Wyoming may be affected by local soil conditions. If fairly soft, saturated sediments are present at the surface, and seismic waves pass through them, surface-ground accelerations will usually be greater than would be experienced if only bedrock were present. Thus, ground accelerations shown by the USGS maps may underestimate the local hazard.

The USGS maps indicate that in the southern part of Carbon County: (1) for the 500-year map (10 percent probability of exceedance in 50 years), the estimated peak horizontal acceleration in Carbon County is about 4%g; (2) for the 1,000-year map (5 percent probability of exceedance in 50 years) is about 3.9%g; and (3) for the 2,500-year map (2 percent probability of exceedance in 50 years) is about 11%g. These accelerations are roughly comparable to intensity V and VI earthquakes. An intensity VI earthquake can result in fallen plaster and damaged chimneys.

The historic record of earthquakes is limited and it is nearly impossible to determine when a 2,500-year event last occurred in the county. This uncertainty, coupled with use by the International Building Code of the record of 2,500-year events for building design, suggests that it is appropriate to use the 2,500-year probabilistic maps for Carbon County analyses.

Honey and Hettinger (2004) have mapped landslide deposits covering about a quarter-section along the north side of Cottonwood Creek in Section 31, T14N:R92W and Section 6, T13N:R92W of the Peach Orchard 7.5-minute topographic quadrangle. These deposits are of limited extent and occur along the contact between the Main Body of the Wasatch Formation and overlying Tipton Tongue of the Green River Formation.

3.2 PALEONTOLOGIC RESOURCES

3.2.1 Paleontological Resource Preservation Act

The Paleontological Resources Preservation Act (PRPA 2009) was signed into law as part of the Omnibus Public Lands Management Act of 2009, Public Law 111-011 (123 Stat. 1173; 16 USC 470aaa) (OPLMA 2009). It states that these resources on federal land (except Indian land) shall be managed and protected "using scientific principles and expertise" and also requires the development of "appropriate plans for the inventory, monitoring, and scientific and educational use of these resources" in accordance with applicable agency laws, regulations, and policies. These plans emphasize interagency coordination and collaborative efforts where possible with non-federal partners, the scientific community, and the general public. In addition, programs to increase the public's awareness about the significance of paleontological resources are to be established.

The PRPA formally defines paleontological resources as "any fossilized remains, traces, or imprints of organisms, preserved in or on the earth's crust, that are of paleontological interest and that provide information about the history of life on earth," and as such include the fossilized remains of plants and animals as well as their traces.

3.2.2 Potential Fossil Yield Classification (PFYC) System

The PFYC system is described in BLM Instruction Memorandum [IM] No. 2008-009, *Potential Fossil Yield Classification (PFYC) System for Paleontological Resources on Public Lands* (BLM 2007d). The IM is summarized here and is included in its entirety in **Appendix D, Paleontological Resources Program Guidance**. The system is based on the premise that the probability of finding paleontological resources can be broadly predicted from the geologic units present at or near the surface. Under the system, geologic units are classified according to the relative abundance of fossils and their sensitivity to adverse impacts, with a higher class number indicating a higher potential.

The PFYC system provides baseline guidance for predicting, assessing, and mitigating paleontological resources. The classification is an intermediate point in the analysis, used to assist in determining the need for further mitigation assessment or actions.

The descriptions for each class (provided below) serve as guidelines rather than as strict definitions. Note that the definition of *fossil* may be redefined in the Rules and Regulations Section of the PRPA, which is still in draft.

Class 1 – **Very Low**. Geologic units that are not likely to contain recognizable fossil remains.

- Units that are igneous or metamorphic, excluding reworked volcanic ash units.
- Units that are Precambrian in age or older.

The probability for impacting any fossils is negligible.

Class 2 – **Low**. Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.

- Vertebrate or significant invertebrate or plant fossils not present or very rare.
- Units that are generally younger than 10,000 years before present.
- Recent eolian deposits.
- Sediments that exhibit significant physical and chemical changes (i.e., diagenetic alteration).

The probability for impacting fossils is low.

Class 3 – **Moderate** or **Unknown**. Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence; or sedimentary units of unknown fossil potential.

- Often marine in origin with sporadic known occurrences of vertebrate fossils.
- Vertebrate fossils and scientifically significant invertebrate or plant fossils known to occur intermittently; predictability known to be low.
- (or)
- Poorly studied and/or poorly documented. Potential yield cannot be assigned without ground reconnaissance.

Class 3a – Moderate Potential. Units are known to contain vertebrate fossils or scientifically significant nonvertebrate fossils, but these occurrences are widely scattered.

Class 3b – Unknown Potential. Units exhibit geologic features and preservational conditions that suggest significant fossils could be present, but little information about the paleontological resources of the unit or the area is known.

Class 4 – **High**. Geologic units containing a high occurrence of significant fossils.

Class 4a – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two acres.

Class 4b – These are areas underlain by geologic units with high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances. Extensive soil or vegetative cover; bedrock exposures are limited or not expected to be impacted. Areas of exposed outcrop are smaller than two contiguous acres; outcrops form cliffs of sufficient height and slope so that impacts are minimized by topographic conditions; other characteristics are present that lower the vulnerability of both known and unidentified paleontological resources.

The probability for impacting significant paleontological resources is moderate to high, and is dependent on the proposed action.

Class 5 – **Very High**. Highly fossiliferous geologic units that consistently and predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils, and that are at risk of human-caused adverse impacts or natural degradation.

Class 5a – Unit is exposed with little or no soil or vegetative cover. Outcrop areas are extensive with exposed bedrock areas often larger than two contiguous acres.

Class 5b – These are areas underlain by geologic units with very high potential but have lowered risks of human-caused adverse impacts and/or lowered risk of natural degradation due to moderating circumstances.

The probability for impacting significant fossils is high.

3.2.3 Known Paleontological Resources in the CD-C Project Area

Known paleontological resources (frequently referred to here as *fossils* or *fossil resources*) within sedimentary deposits in the project area record the history of animal and plant life in Wyoming during the early part of the Cenozoic Era (Paleocene and Eocene Epochs) and the latest part of the Mesozoic (Cretaceous Period) Era. As described above, current mapping documents six geologic deposits exposed at the surface in the project area. These include, from youngest to oldest: (1) unnamed deposits of Quaternary (Holocene to Pleistocene) age, (2) the middle Eocene Battle Spring Formation, (3) the middle and early Eocene Green River Formation, (4) the Wasatch Formation of early Eocene age, (5) the Fort Union Formation of Paleocene age, and (6) the Lance Formation of Latest Cretaceous age.

With the exception of the Holocene deposits that are probably too young to contain fossils, all sedimentary rock units exposed in the project area are known to produce or have the potential to produce scientifically significant fossil resources. Scientifically significant fossils have been recovered from the Wasatch (Morris 1954; Honey 1988; Roehler 1972, 1991a–b, 1992a–c, 1993; Roehler *et al.* 1988), Fort Union (Rigby 1980, Winterfeld 1982), and Lance Formations (Dorf 1942, Estes 1964, Clemens 1986, Clemens *et al*. 1979, Breithaupt 1982 and 1985, Weishample 1992, Archibald 1993, Lillegraven 2002, Honey 2003) within the project area or immediately adjacent areas.

Specifically, 15 fossil localities are known to occur within the project area in the Lance Formation and 17 fossil localities are known to occur within the Fort Union Formation. The Lance Formation localities occur in the Separation Peak (T20N:R90W), Fillmore Ranch (T18N:R20W), Doty Mountain (T17N:R91–92W), Peach Orchard Flat (T15N:R91W) and Blue Gap (T15N:R91W) 7.5-minute Quadrangles. The Fort Union Formation localities occur in the Separation Peak (T20N:R90W), Fillmore Ranch (T19N:R91W), Duck Lake (T16–17N:R91-91W), Mexican Flats (T16N:R92W) and Blue Gap (T15–16N:R91–92W) 7.5-minute Quadrangles. Localities from both the Lance and Fort Union Formations produce a wide variety of fossil remains, including those of mammals, reptiles, amphibians, and fish. Of great importance is the occurrence within the Fort Union Formation of some of the oldest known Paleocene-age fossil vertebrates in the world, which are considered to be of Puercan age (earlier Paleocene) and are very rare (Honey 2003).

Literature review and the field survey documented the occurrence of known scientifically significant fossils within the CD-C area in the following formations: (1) the middle Eocene Battle Spring Formation (PFYC 3b [unknown]), (2) the middle and early Eocene Green River Formation (PFYC 5, very high), (3) the Wasatch Formation of early Eocene age (PFYC 5, very high), (4) the Fort Union Formation of Paleocene age (PFYC 3a, moderate), and (5) the Lance Formation of Latest Cretaceous age (PFYC 5, very high).

3.2.4 Taphonomy and the Occurrence of Fossils

Taphonomy is the study of the origin and nature of accumulations of fossil materials or their traces. In general, vertebrate fossils are much rarer than invertebrate fossils, but there are sites where extraordinary accumulations of fossil vertebrates are found.

Knowledge of the geologic context of vertebrate fossils collected at a site is critically important in evaluating the reason fossils occur where they do. The geological context of a deposit contains information about whether the deposit formed under marine (ocean), lacustrine (lake), or fluvial (riverine) conditions. In the project area, five geological formations have high potential for yielding fossil vertebrates. From oldest to youngest, these are: (1) the Lance Formation (Upper Cretaceous), (2) the Fort Union Formation (Paleocene), (3) the Wasatch Formation (lower Eocene), (4) the Green River Formation (middle Eocene), and (5) the Battle Spring Formation (middle Eocene). None of these formations is of marine origin, and only the Green River Formation was deposited under largely lacustrine conditions. The Lance, Fort Union, Wasatch, and Battle Spring formations are dominantly of fluvial (river, stream, and associated floodplain) origin.

In lacustrine environments, fossil vertebrate remains might accumulate in shales deposited under open-water conditions or, closer to shore, in units containing coarser clastic material. Fluvial sediments (those deposited by streams) represent two basic environments: the channel and the floodplain. Channel deposits are generally dominated by sandstone and/or gravel conglomerate, whereas floodplain sediments consist chiefly of mudstones. Because they were subjected to periodic drying during intermittent deposition, rocks comprising floodplain deposits are commonly color-variegated. The thicknesses of the colored horizons reflect the relative maturity (relative time to form) of the ancient soils (Bown and Kraus 1980a and 1980b).

In fluvial rocks, the accumulation of vertebrate material may be either active or passive. Active accumulation involves the concentration of bones by running water. All fossil vertebrate concentrations formed by active accumulation are made up of remains that have been transported after death, although they need not have been transported very far.

Passive accumulation includes all mechanisms of concentrating fossil material in fluvial environments in which the remains of the organism are not transported to a large extent after death. Examples of passive accumulation include: (1) the slow buildup of bones in quicksand deposits, (2) the preservation of remains as a result of ash-falls, and (3) the gradual accumulation of the remains of dead animals in the upper (A) horizons of soils (paleosol accumulations). Because paleosols are ubiquitous in ancient fluvial sequences, and because floodplains with forming soils occupy more than 98 percent of the area of any basinal area of fluvial accumulation, the vast majority of vertebrate fossils accumulate as part of passive paleosol accumulations (Bown and Kraus, 1981b). Paleosols, like modern soils, form between times of major (depositional) events. The amount of vertebrate remains that accumulates during these events can be staggering. If only three bones/year accumulated on a soil surface 247 acres in area, as a paleosol that formed for 50,000 years, that soil might be expected to yield 150,000 individual bones.

Lance Formation

The presence of fossil localities of scientific significance in the Lance Formation is well established and has a long history (Breithaupt 1982). One of the earliest discoveries was the remains of a horned dinosaur (ceratopsian) discovered about 15 miles southeast of Point of Rocks near the old Black Butte Stage Station in 1872. These remains were identified as the new species *Agathaumus sylvestris* by Cope in 1872 and represent the first dinosaur remains found in strata now referred to as the Lance Formation.

Within the project area, the Upper Cretaceous Lance Formation consists of up to 2,900 feet of interbedded gray sandstone and sandy mudstone, carbonaceous shale, and coal. The Lance Formation is well-known for its dinosaurian remains (Breithaupt 1982); however, the only Lance fossil vertebrates found within the project area are some rare fish and crocodilian remains, as well as a few mammal teeth collected from anthills (J.G. Honey 2003). The provenance of these remains is uncertain, but they probably came from poorly developed paleosols.

Fort Union Formation

The Fort Union Formation is exposed within the project area as up to 3,400 feet of drab mudstone, sandy mudstone, sandstone, carbonaceous shales, and coal. Fossil vertebrates—especially mammals—are well-known from Fort Union rocks in and adjoining the study area (Rigby 1980; J.G. Honey 2003), the most noteworthy localities being Swain Quarry, in Section 3, T15 N:R 92 W, and another site in the basal part of the formation discovered by J.G. Honey, the paleontologist cited in the reference above. Swain Quarry yields principally mammal teeth from a sandstone, and both that site and the new site discovered by Honey are almost certainly gradual active accumulations of bones on point bars of meandering streams. Winterfeld (1982) has recorded the occurrences of fossil vertebrates in greenish to greenish-gray Fort Union mudstones. As these deposits are relatively thin and tabular in nature, it is quite likely that they represent the “A” horizons of relatively mature damp paleosols, and are therefore *passive accumulations*.

Wasatch Formation

The Ramsey Ranch Member, Main Body of the Wasatch Formation and the Niland and Cathedral Bluffs Tongues of the Wasatch comprise bedrock exposures of the Wasatch Formation within the project area.

Numerous fossil vertebrates, invertebrates, and trace fossils are known from the Main Body throughout southern Wyoming (Granger 1916; Gazin 1952, 1956, 1962; 1965; McGrew and Roehler 1960; West 1973), including deposits previously referred to as the Knight and Almy “formations” by Veatch (1907). These fossils include somewhat more primitive forms of rodents, carnivores, early horses, artiodactyls, and condylarths than those in the stratigraphically younger Cathedral Bluffs Member and range between early to middle early Eocene (early to late Wasatchian) in age.

Fossil vertebrates are locally abundant in the Wasatch Formation, including all the subunits that comprise the formation in the project area. Fossils are most abundant where they have weathered from immature through mature paleosols. However, about 10 miles north of Baggs, Wyoming, sandstones of the Cathedral Bluff Member that interfingers with the Tipton Shale have produced fossils of 11 mammalian species including primates, condylarths, tillodonts, dinocerates, and perissodactyls (Roehler 1988) as well as the fossils of mollusks, ostracodes, and burrows, worm trails, and an unidentified tubular impression. The mollusks include very abundant shells of the gastropods *Goniabasis* and *Viviparu,s* as well as freshwater unionid bivalves. These fossil-bearing sandstones represent deposition in a delta system prograding into Lake Gosuite. West of the project area, Wasatch vertebrates are described as coming from drab, carbonaceous mudstones containing the remains of terrestrial mollusks (Savage *et al.* 1972; Gazin, 1962; Savage and Waters, 1978; Williams and Covert, 1994). These deposits appear to be damp paleosols.

Green River Formation

The Laney Shale (including LaClede and Hartt Cabin beds), Godiva Rim, Wilkins Peak (lower part only) members and Tipton (including the Scheggs and Rife beds) and Luman tongues comprise bedrock exposures of the Green River Formation within the project area (Roehler 1991a, 1991b, 1992a, 1992b, 1992c, 1993).

Apparently, the only fossils known from the Godiva Rim Member are ostracodes. The Laney Shale is quite fossil-rich in places and is well-known for its fossil fish. Fossil gastropods, bivalves, and fish are common in the LaClede Bed. Small planorbid gastropod fossils of *Gyralus militaris* are extremely abundant and widespread in one particular layer (about a foot thick) that is recognized as a stratigraphic marker bed, the Gyralus Marker Bed. Impressions of plants and insects also occur in some shales of the LaClede Bed. Stromatolites—the remains of ancient reefs—also characterize the unit. Some of the stromatolies may be as much as 25 feet high and 10 feet wide. The Hartt Cabin Bed produces abundant fossil vertebrates, mostly fish, but also reptiles and mammals, along the eastern edge of the Washakie Basin at Willow Creek.

Plant, invertebrate, and vertebrate fossils have been reported from the Wilkins Peak Member elsewhere in Wyoming (Grande 1984, 1989; Olsen 1987, 1992). Roehler (1974) noted a fossil bird locality in the member south of Rock Springs at Scrivner Butte. Another fossil bird locality occurs a few miles away in the Four J Rim Quadrangle. This locality has yielded the dissociated skeletons, including skulls, of the wading bird *Presbyornis.* The number of individual birds preserved in the layer may number into the many thousands. Hundreds of fossil flamingo bones, apparently the remains of a large nesting colony, have been collected from a locality developed in rocks of the lower part of the member at a locality discovered near Oregon Buttes in gray-green lake claystone (McGrew and Feduccia 1973). The locality was originally described as occurring in the Cathedral Bluffs Member of the Wasatch Formation, but its location in lake sediments means that the locality actually occurs in the Wilkins Peak Member.

The Scheggs Bed preserves the fossil remains of ostracodes, gastropods, such as *Goniabasis tenera* and *Viviparus* sp., and the large unionid bivalve *Lampsilis*. Fish fossils also occur abundantly along outcrops of the Scheggs Bed (Roehler 1991a, 1991b, 1992a, 1992b, 1992c, 1993). One fossil mammal locality occurs in the Scheggs Bed and this locality, discovered in an ostracodal limestone along Parnel Creek a few miles north of Rock Springs, (T24N:R102W) produced the mold of a jaw of the early horse Hyracotherium, with incisors and molar impressions. Roehler (1992c) noted that fossil fish are locally abundant in the Rife Bed in the Sand Wash and Washakie basins.

Fossils of freshwater molluscs are abundant throughout the Luman Tongue and the assemblages of fossils are commonly characterized by the large prosobranch gastropods *Goniabasis tenera* and *Viviparus* sp. and by the large unionid bivalve, *Lampsilis* sp. Fish, ostracod, and trace fossils are also common in the unit.

Battle Spring Formation

The Battle Spring Formation was named by Pipiringos (1955) for up to 3,300 feet of arkosic sandstone that "… intertongues with … the Red Desert, Niland, and Cathedral Bluffs tongues of the Wasatch Formation, and the Lumen and Tipton tongues and Laney Shale Member of the Green River Formation" (Pipiringos 1961). Love and Christiansen (1985) mapped Battle Spring rocks as far south as I-80 west of Rawlins, and included in it several hundred feet of gray, green, gold, and red mudstones, thin arkosic ribbon sandstones, and carbonaceous shales. No fossil vertebrates have been reported from Battle Spring rocks within the project area; however, bone fragments, including one of a fossil bird, were found in red mudstones (paleosols) during a reconnaissance survey for this study.

3.3 SOILS

Soils in the CD-C project area vary widely, but are predominantly formed from residuum on bedrock-controlled uplands and alluvium in playas (BLM 1999). Residuum refers to unconsolidated, weathered, or partly weathered mineral material that accumulates by disintegration of bedrock in place. Variable average annual precipitation patterns exist across the project area, with three different precipitation gradients that range from 7 to 9, 10 to 14, and 15 to 19 inches. The project area is dominated by the 10- to 14-inch precipitation zone with the northwest corner of the project area in the 7- to 9-inch precipitation zone and a small portion in the southeast area in the 15- to 19-inch precipitation zone (Texas Resource Consultants [TRC] 1981; Wells *et al.* [Wells] 1981).

Two Order 3 soil surveys were previously completed by the BLM in cooperation with the Soil Conservation Service [now known as the Natural Resources Conservation Service, NRCS] for most of the CD-C project area (TRC 1981; Wells et al. 1981). For areas not covered by the existing soil surveys, Order 3 field mapping was completed by KC Harvey Environmental, LLC during May 2007. During the field mapping, existing soil-mapping units from the TRC and Wells 1981 surveys were extended into the unmapped areas of the project area using aerial imagery. The proposed soil map unit boundaries in the unmapped areas were then verified in the field by sampling the soils to a depth of 60 inches with a Giddings probe (Giddings Machine Company, Colorado).

A total of 387 soil complexes, associations, taxadjuncts, and variant map units occur within the 1,070,086 acres that comprise the CD-C project area. A total of 286 soil series comprise the 387 map units.

The majority of the project area is used as rangeland for domestic livestock grazing, wildlife habitat, and recreation. A small portion of the area is used for production of native hay, both irrigated and dryland, and utilization of wood for fence posts and firewood (TRC 1981; Wells *et al.* 1981). Since the 1950s, development of the area's natural gas resources has become a major land use.

3.3.1 General Description of Major Soil Types

Soils in the project area were formed from erosion of bedrock exposed at the surface and from lacustrine, alluvium, loess, and eolian deposits (BLM 1999). The parent material in the project area is dominated by tertiary shales and sandstones and uplifted cretaceous sedimentary rock (Munn and Arneson 1998). Soils on the tertiary bedrock are poorly developed with little clay accumulation. Sandy soils occur on stabilized sand dunes and in areas with active dunes. Saline soils exist in playas, and sodic soils occur on alluvial fans derived from high-sodium parent materials. The project area contains soil orders of alfisols, inceptisols, mollisols, and aridisols. All soils within the project area have a frigid temperature regime. Soil texture is a mix of fine-loamy, coarse-loamy, and sandy materials. Slopes are generally level to undulating (zero–10 percent) and are separated by areas with steeper slopes (10–40 percent) to vertical slopes (rock outcrops).

3.3.2 Soil Limitations

To assess the potential limitations of the CD-C project area soils, five areas of concern were addressed: water erosion, wind erosion, runoff potential, local road construction limitations, and reclamation potential. These were evaluated using soils information from the two soil surveys completed by the BLM (TRC 1981; Wells *et al.* 1981). Results are summarized in **Table 3.3-1** and a discussion of each category is provided below.

Information from individual soil map units was used to evaluate the soil limitations. If multiple soil series existed within a single map unit, rankings were assigned based on the soil series that comprised the greatest acreage within the unit. To provide the most unbiased ranking, assignments were made using the relative size of the included soil series rather than the most limiting or the least limiting soil series within the map unit.

To ascertain the distribution of potential soil limitations for existing natural gas disturbances, the number of current wells drilled in each of the rating class areas for each limitation was determined.

Table 3.3-1. Potential soil limitations in the CD-C project area

Potential Limitation	Rating Class/Limiting Features	Acres	% Total Area	% of Disturbance in Each Class[2]
Water Erosion	Slight	748,850	69.9	72.8
	Moderate	230,713	21.5	21.5
	Severe	45,808	4.3	3.0
	Not Rated / Water	45,552	4.3	2.8
Wind Erosion	Slight	100,534	9.4	13.6
	Moderate	859,633	80.3	77.7
	Severe	65,204	6.1	5.9
	Not Rated / Water	45,552	4.3	2.8
Runoff Potential	Low	19,686	1.8	0.5
	Low To Moderate	21,416	2.0	0.9
	Moderate	362,499	33.8	6.6
	Low to High	67,473	6.3	35.5
	Moderate to High	237,355	25.0	29.6
	High	299,336	28.0	24.6
	Not Rated / Water	33,158	3.1	2.3
Road Construction	Moderate	680,344	63.5	63.8
	Moderate / Severe	703	0.1	0.0
	Severe	348,732	32.6	33.5
	Not Rated / Water	41,145	3.8	2.7
Rationale[1]	Shallow to Bedrock	55,597	5.2	3.2
	Low Strength Soils Present	902,656	84.4	87.3
	Shrink-Swell Soils Present	8,544	0.8	1.3
	Soils Too Sandy	52,110	4.9	5.4
	Wet Conditions	9,671	0.9	0.0
	No Rationale	40,934	3.8	2.7
Reclamation Potential	Good	221,785	20.7	13.7
	Fair	269,565	25.2	26.2
	Poor	537,228	50.2	57.4
	Not Rated / Water	40,934	3.8	2.7
Reclamation Rationale[1]	High Soil Salinity Levels	449,199	42.0	54.4
	Large Stones Present	4,678	0.4	0.4
	Soils Too Clayey	288,034	26.9	23.0
	Soils Too Sandy	57,433	5.4	5.5
	Wet Conditions	4,972	0.5	0.0

[1] *For the Road Construction Limitation and Reclamation Rationale, the limiting features should not sum to the total project acreage, as a single soil could be limited by several of the features listed.*

[2] *The percentage of disturbance in each class is estimated as the percentage of current wells located in each category.*

3.3.2.1 Water Erosion

To assess the potential for soil erosion caused by water, the soil erosion factor (K) obtained from data recorded by TRC and Wells in 1981 and soil slope data were used to rank the CD-C project area soils for susceptibility to erosion. Slope data were derived from the digital elevation model for the project area. The K indicates the susceptibility of a soil to sheet and rill erosion (Institute of Water Research 2002). It is one of the six factors used in the Revised Universal Soil Loss Equation to predict the average annual rate of soil loss by water erosion. The K is based on percentage of silt, sand, organic matter, soil structure, and hydraulic conductivity. The soil-surface horizon K was used to group the project area soils into water-erosion classes.

The values for K factors and slope ranges used to group the soil into slight, moderate, and severe water-erosion classes are provided in **Table 3.3-2**. The K value and percent slope data were queried to determine the surface area relative to the slight, moderate, and severe erosion classes. These data were plotted on **Map 3.3-1** to illustrate the potential for water erosion in the CD-C project area. Overall, the susceptibility to water erosion is slight, with 748,850 acres or 69.9 percent of the project area rated as having slight water-erosion potential (**Table 3.3-1**). Only 4.3 percent of the project area, or 45,808 acres, is rated as having a severe water-erosion potential. The large percentage of area classified as having slight water-erosion potential is controlled by the flat slopes that occur throughout the project area.

Table 3.3-2. Water erosion classes determined by Erosion Factor (K) and Slope in the CD-C project area

Erosion Factor (K)	Water Erosion Class		
	Slight	Moderate	Severe
	Slope (%)		
<0.2	<20	20 to 40	>40
0.2 to 0.32	<15	15 to 35	>35
>0.32	<10	10 to 20	>20

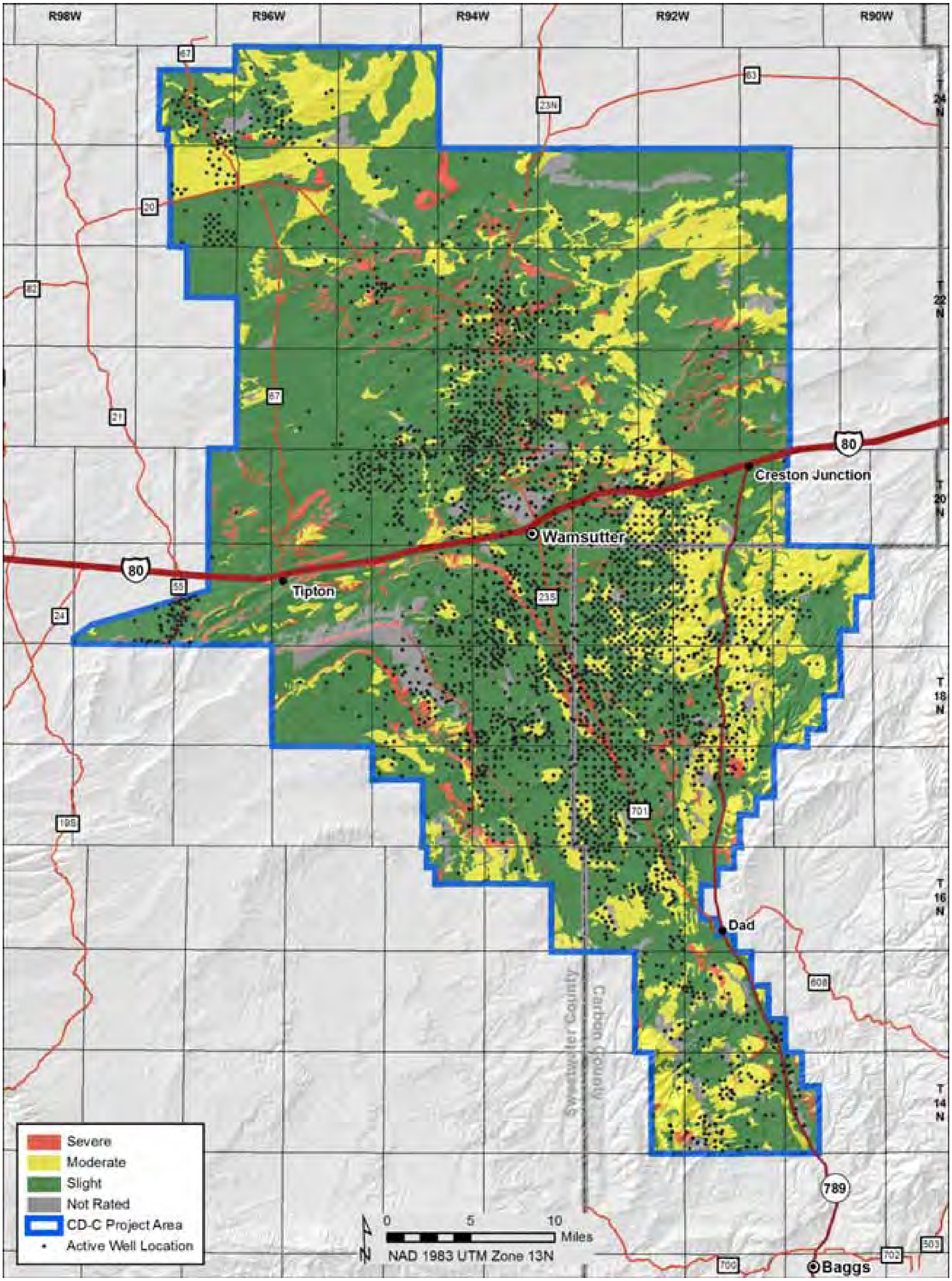
At present 72.8 percent of the total wells currently drilled within the CD-C project area are located within soils that have a slight risk for water erosion.

3.3.2.2 Wind Erosion

To assess the potential of soil erosion by wind, the wind-erodibility class was obtained from data recorded by Texas Resource Consultants (1981) and Wells *et al*. (1981). Wind-erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. Soils are grouped according to percent sand, silt, and clay; calcium carbonate content; presence of surficial coarse fragments; and surface-wetness conditions.

The potential for wind erosion in the CD-C project area is shown on **Map 3.3-2**. Soils within the 1 and 2 wind-erodibility groups are classified as a severe limitation for wind erosion; soils in the 3, 4, and 4L wind-erodibility groups are considered as a moderate limitation for wind erosion; and soils in the 5, 6, 7, and 8 wind-erodibility groups have a slight limitation for wind erosion (TRC 1981, Wells *et al.* 1981). A moderate limitation because of wind erosion exists for 80 percent of the total project area or 859,633 acres (**Table 3.3-1**). Only 9.4 percent or 100,534 acres and 6.1 percent or 65,204 acres, respectively, are rated to have slight and severe limitations to wind erosion, respectively.

At this time, 78 percent of the total wells currently drilled within the CD-C project area are located within soils that have a moderate limitation for wind erosion.



Map 3.3-1. Water-erosion potential for the CD-C project area

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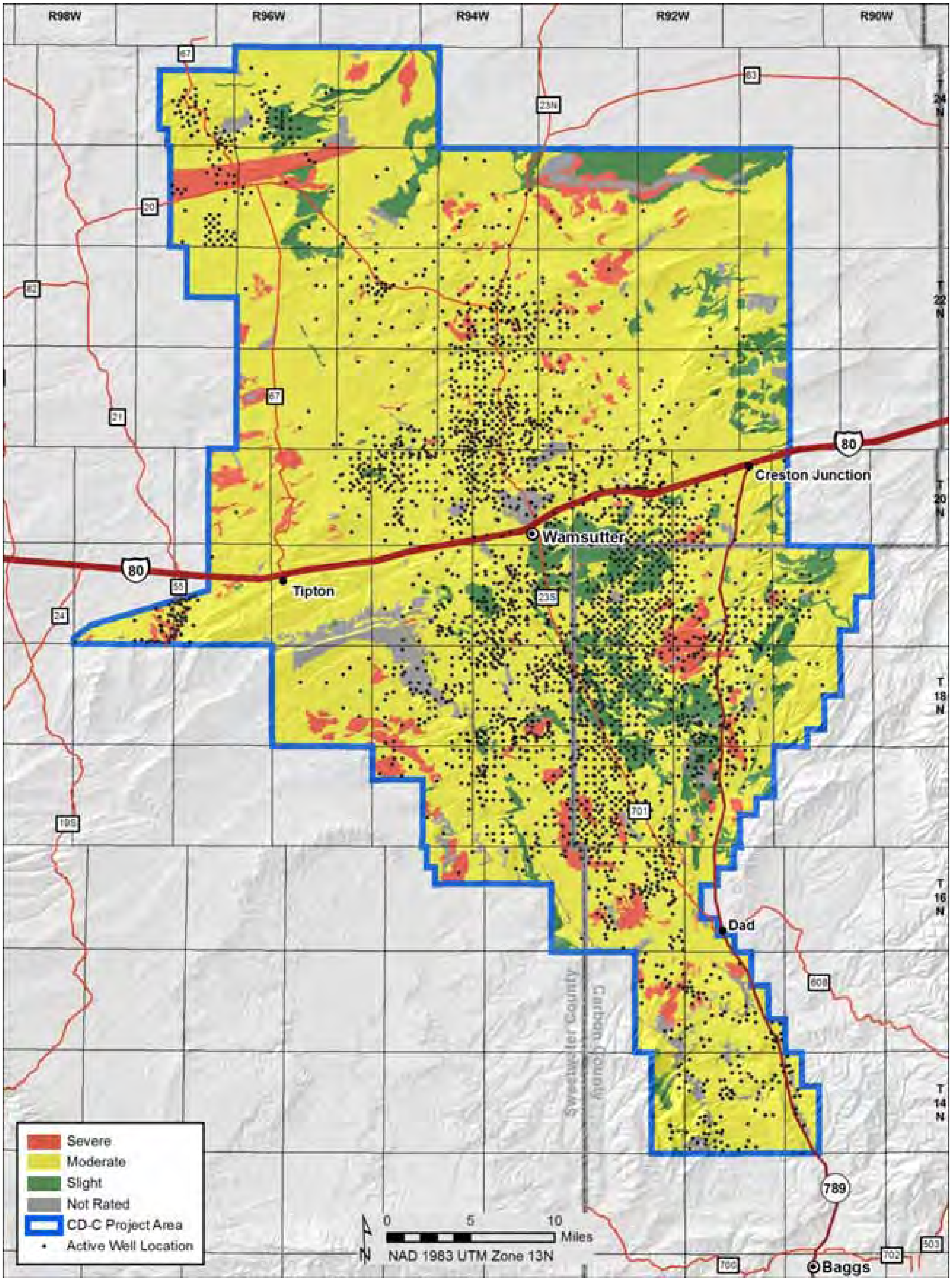


Map 3.3-2. Wind-erosion potential for the CD-C project area

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

3.3.2.3 Runoff Potential

To assess the potential for surface runoff, the hydrologic soil group was obtained from Texas Resource Consultants (1981) and Wells *et al.* (1981). The hydrologic soil group classifies soils according to their runoff-producing characteristics, which include depth to the water table, infiltration rate, permeability after prolonged wetting, and depth to the lowest permeable layer. Also, site-specific factors relating to management practices are considered, such as compaction, crusting, organic matter, and vegetative cover. The hydrologic group rating only considers the potential for runoff when soils are thoroughly wet and does not consider the slope of the soil.

The potential for surface runoff in the CD-C project area is shown on **Map 3.3-3**. Soils within Hydrologic Soil Group A are considered to have a low runoff potential, Hydrologic Soil Group B soils have a moderate runoff potential, and Hydrologic Soil Groups C and D soils are considered to have a high runoff potential. Surface-runoff potential was predominantly moderate, composing 34 percent of the project area or 362,499 acres (**Table 3.3-1**). A rating of high runoff potential was given to 299,336 acres or 28 percent of the CD-C project area.

At this time, 36 percent of the total wells currently drilled within the CD-C project area are located within soils that have a moderate runoff potential.

3.3.2.4 Road Construction

To assess the degree of limitation to the construction of roads, unsurfaced road ratings were obtained from TRC (1981) and Wells *et al.* (1981). Road rankings were based on depth to bedrock, soil strength, shrink/swell potential, soil texture, large surface stones, slope, and surface wetness.

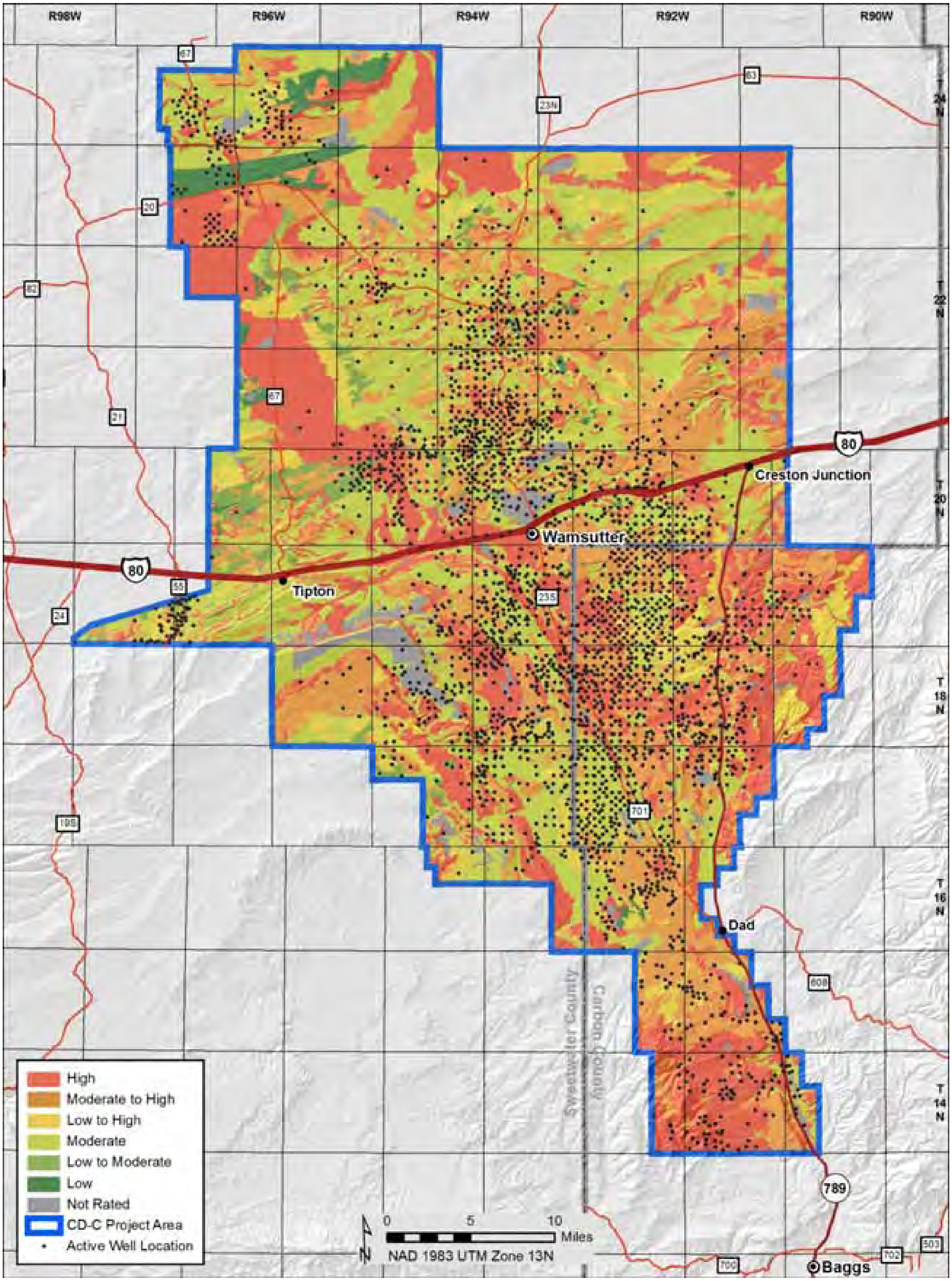
The potential limitation for the construction of roads in the CD-C project area is shown in **Map 3.3-4**. The CD-C project area is predominantly rated as having a moderate limitation for road construction, with 63.5 percent, or 680,344 acres, having this rating (**Table 3.3-1**). The limiting features to road construction are provided in Table 3.3-1. Soil strength, depth to bedrock, and sandy soil textures are the main limitations to construction in the CD-C project area.

At present, 64 percent of the total wells currently drilled within the CD-C project area are located within soils that have moderate limitations to road construction.

3.3.2.5 Reclamation Potential

Reclamation is the reconstruction of topographic, soil, and plant conditions following disturbance to allow the area to fully function as part of the ecosystem (Munshower 1994). The BLM’s long-term objective of final reclamation is to set the course for eventual ecosystem restoration, including the restoration of the natural vegetation community, hydrology, and wildlife habitats. In most cases, this means returning the land to a condition approximating or equal to that which existed prior to the disturbance. The Operator must achieve short-term stability, visual, hydrological, and productivity objectives of the surface-management agency and must take steps to ensure long-term objectives will be reached though natural processes (USDI and USDA 2006).

To determine reclamation potential of the CD-C project area soils, the topsoil rating presented in the soil surveys prepared by Texas Resource Consultants (1981) and Wells et al. (1981) was used as a direct correlation of the soil reclamation potential. Soils having good, fair, or poor topsoil ratings are classified on **Map 3.3-5** as having good, fair, and poor reclamation potential, respectively. The soil classifications defined in the soils survey are influenced by many factors such as rainfall, slope, and aspect in addition to the physical and chemical composition of the soil. The direct correlation used between topsoil rating and soil reclamation potential indirectly considers the factors that would be favorable or unfavorable for soil reclamation.



Map 3.3-3. Runoff potential in the CD-C project area

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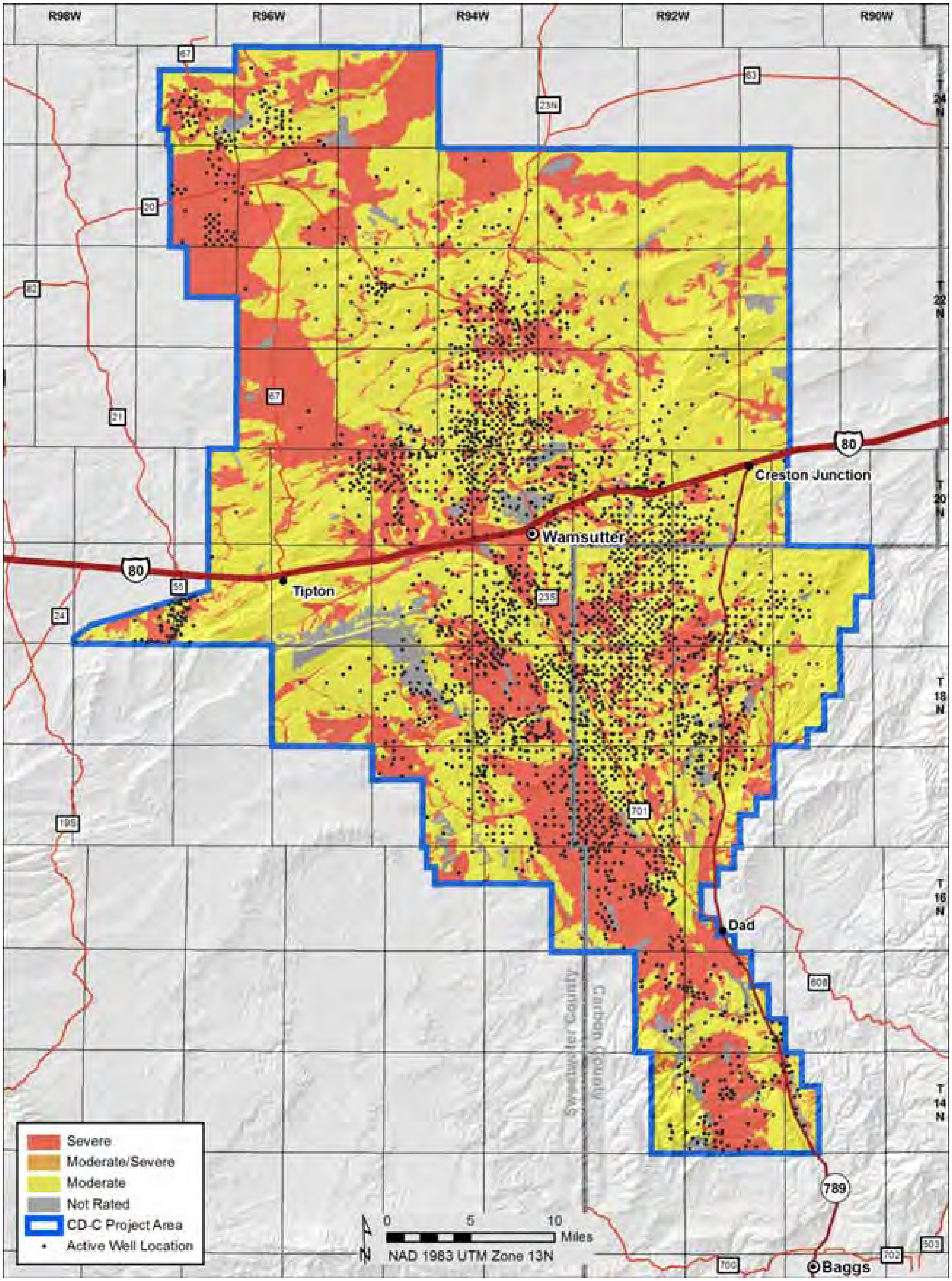

Map 3.3-4. Potential road construction limitations in the CD-C project area

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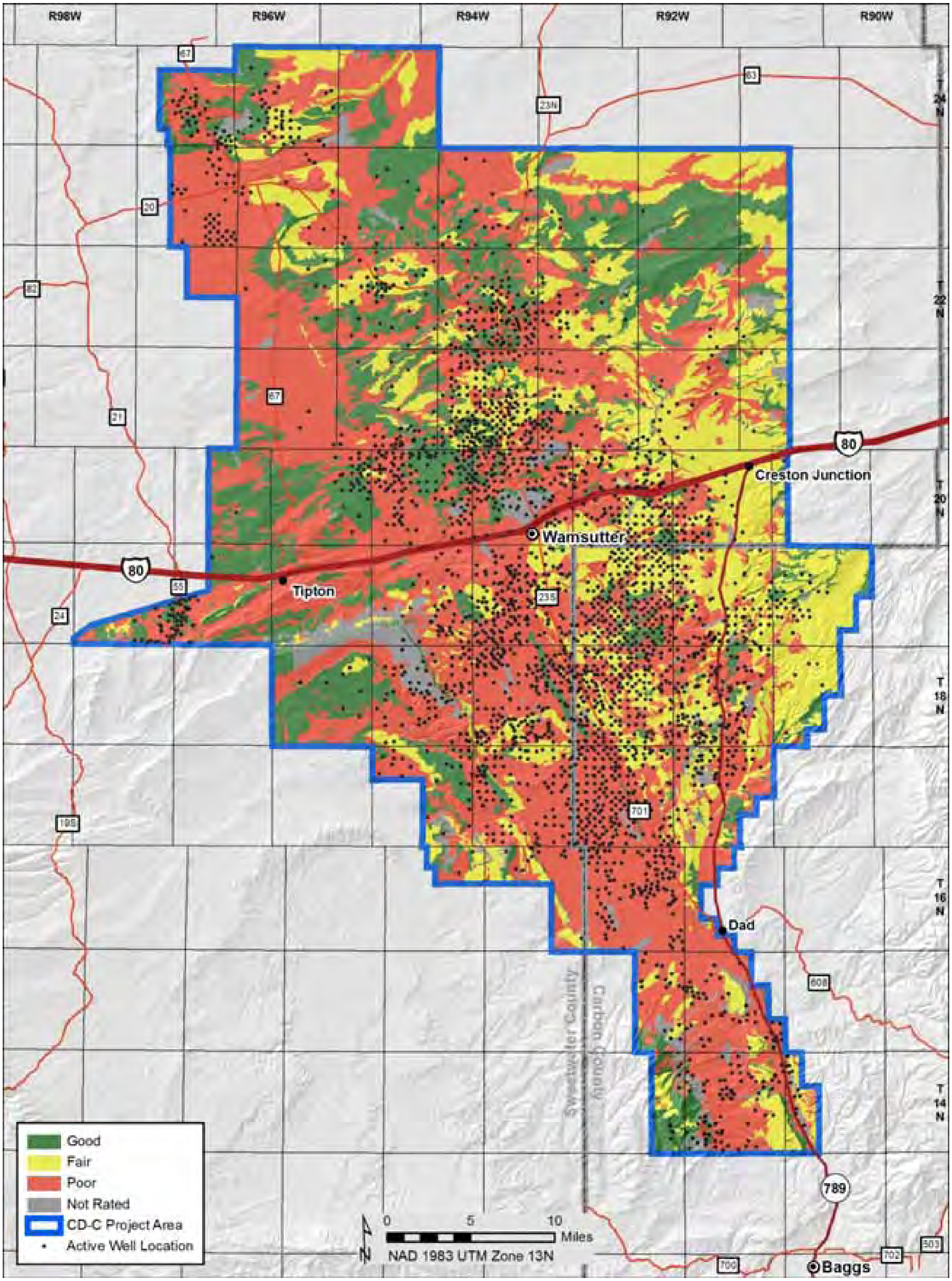

Map 3.3-5. Reclamation potential for soils in the CD-C project area

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The reclamation potential of the CD-C project area is primarily poor, with 537,228 acres or 50 percent of the total project acreage having this rating (Map 3.3-5, **Table 3.3-1**). Locations identified as “No Rating” on Map 3.3-5 generally consist of rock outcrops or rock surfaces that did not include a topsoil rating since topsoil is not present in these locations.

Rankings of fair and good were given to 25 percent or 269,565 acres, and 21 percent or 221,785 acres of the CD-C project area, respectively. The limiting features to reclamation are provided in **Table 3.3-1**. Saline/sodic soil conditions and either clayey or sandy soil textures are the main limitations to reclamation of the CD-C project area.

At this time, 57 percent of the total wells currently drilled within the CD-C project area are located within soils that have poor reclamation potential. For the currently drilled well locations with limitations to reclamation, the main limitation to reclamation is saline/sodic soil conditions.

3.3.3 Watershed-Based Land Health Assessment

In 2008 the RFO finished conducting Standards and Guidelines Assessments for all the watersheds within the field office. These are watershed-based land health assessments mandated by the Director of the BLM on a 10-year basis. From 1998 through 2000, the RFO conducted Standards and Guidelines Assessments on an allotment basis; however, in 200, in order to meet this 10-year timeframe, larger-scale watershed-based reports were undertaken. The Upper Colorado River and the Great Divide Basin were the first two watershed reports completed (2002 and 2003, respectively), and are due for reassessment over the next three years, at which time progress towards management objectives will be evaluated. Standard 1 – Watershed Health, states that “[w]ithin the potential of the ecological site (soil type, landform, climate, and geology), soils are stable and allow for water infiltration to provide for optimal plant growth and minimal surface runoff” (BLM 2001a). Standard 1 is considered met if upland soil cover generally exceeds 30 percent and obvious signs of soil erosion are not apparent, and if stream channels are stable and improving in morphology. Key watershed health-related issues identified by the Standards and Guidelines Assessment for the Upper Colorado River and Great Divide Basin include erosion from improved and unimproved roads, and short- and long-term erosion from oil and gas field development.

During the 2001 field season, project area watersheds within the Upper Colorado River Basin were assessed (BLM 2002). Barrel Springs Draw, a sub-watershed within the Muddy Creek watershed, and the Lower Sand Creek sub-watershed within the Little Snake River watershed, were determined to meet Standard 1. The Upper Muddy Creek and Lower Muddy Creek sub-watersheds within the Muddy Creek watershed did not meet Standard 1. Holler Draw and Chicken Springs Wash in the Upper Muddy Creek watershed (2,500 acres), and Little Robber and Cottonwood Creek in the Lower Muddy Creek watershed (6,000 acres) have large, active head-cuts caused by gradient readjustment processes; therefore, because the stream channels are not stable, these areas did not meet Standard 1.

During the 2002 field season, project area watersheds within the Great Divide Basin were assessed (BLM 2003). All sub-watersheds, including Battle Springs Flat, Buck Draw, Cyclone Draw, Latham Draw, Red Creek, Red Desert Basin, Red Wash Draw, Salt Sage Draw, and Upper Separation Creek were determined to meet Standard 1.

3.4 WATER RESOURCES

Water resources in the CD-C project area include both surface water and groundwater. A majority (approximately 70 percent) of the project area is located within the Great Divide Basin (hydrologic unit code [HUC] 14040200). Approximately 29 percent of the project area is within the White-Yampa Basin (HUC 140500) and 1 percent is within the Upper Green Basin (HUC 140401). Watershed basins within the project area are shown on **Map 3.4-1**. Surface water in the Great Divide Basin drains internally, with no surface hydrologic outlet. The Upper Green and White-Yampa watersheds are part of the Upper Colorado Basin (HUC 14).

Groundwater resources in the project area include unconfined (water table) and confined aquifers. The unconfined aquifers are generally shallow, blanket-type deposits of Quaternary or Tertiary age and are generally found within 400–600 feet of the ground surface. Alluvial deposits fall into this category. Confined aquifers are bound by relatively impermeable rocks and are generally in the deeper formations, such as the Mesaverde Group. Most of the geologic formations of pre-Oligocene age in the project area contain water under confined pressure (Welder and McGreevy 1966). Conventional oil and gas wells would be completed in the Almond Formation in the Mesaverde Group at depths between 8,000 and 12,000 feet. Coalbed natural gas (CBNG) development, if undertaken, would primarily target the Fort Union Formation with secondary reserves targeted in the Wasatch, Frontier, and Lance formations at depths between 550 and 7,700 feet.

3.4.1 Climate and Precipitation

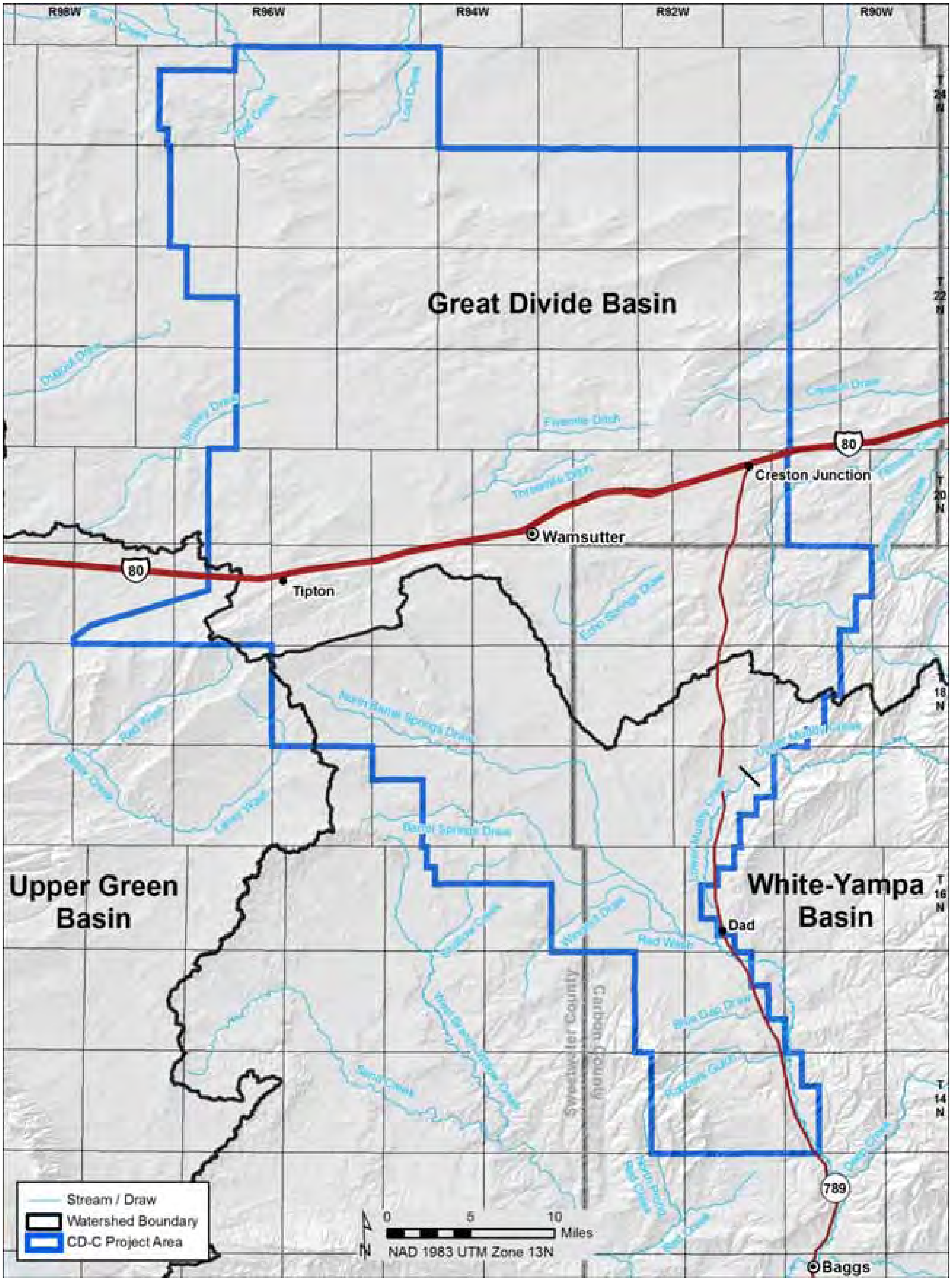
Climate and precipitation, as detailed in **Section 3.5** (**Air Quality**), greatly influence the character and condition of the surface and groundwater resources. The project area is located in a continental dry, cold-temperature-subarctic climate (Trewartha 1968). The climate is characterized by precipitation deficiency, where potential evaporation exceeds precipitation. Temperatures are generally cold, with fewer than eight months of the year having an average temperature greater than 50° F. Summer days are warm, summer nights are cool, and winters are cold. Strong and prolonged winds periodically sweep the project area throughout the year, being especially prevalent in winter.

These climatic conditions (low precipitation and high evaporation rates) result in the prevalence of surface water features in the project area with ephemeral or intermittent flows. The climatic conditions are reflected in the limited amount of shallow groundwater and the prevalence of confined aquifer systems. Recharge to the groundwater systems generally occurs at higher, distant elevations, with limited local recharge to the shallow aquifers.

3.4.2 Surface Water

There are three major drainage basins associated with the project area (**Map 3.4-1**). The Continental Divide runs east and west across the central portion of the project area. Drainages in the project area south of the Continental Divide flow into the Upper Green Basin or the White-Yampa Basin. Tributaries to Bitter Creek drain the portion of the project area within the Upper Green Basin. Bitter Creek flows to the Green River, which flows to the Colorado River, and ultimately to the Pacific Ocean. Tributaries to the Little Snake River drain the portion of the project area within the White-Yampa Basin. The Little Snake River flows to the Yampa River, which flows southwest to its confluence with the Green River in Colorado. Drainage north of the Continental Divide is contained in the Great Divide Basin. As mentioned above, the Great Divide Basin is internally drained, with no surface hydrologic outlet.

Just over 1 percent of the project area is within the Upper Green Basin. Tributaries to Bitter Creek (Red Wash and Laney Wash) begin in the project area and flow out of the area to the southwest (**Map 3.4-1**). Surface water hydrology data are limited for the portion of the project area within the Upper Green Basin due to the dry nature of the climate and resulting minimal stream-flow in the area.



Map 3.4-1. CD-C project area with watershed basins and streams

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Very small portions of the White-Yampa Basin within the project area are drained by Willow Creek/Shallow Creek (tributaries to Sand Creek) and the North Prong of Red Creek. The remainder of the White-Yampa Basin within the project area is drained by Muddy Creek and its tributaries. Muddy Creek is the dominant water feature within the project area and it flows into the perennial Little Snake River, immediately south of the project area (**Map 3.4-1**).

Most surface water flow within the Great Divide Basin is ephemeral (occurring only in response to localized rainfall or snowmelt) or intermittent (flowing water during certain times of the year, when groundwater provides water for stream flow). The only streams in the Great Divide Basin with perennial flow are the upper portion of Separation Creek, in the Atlantic Rim area, and Lost Soldier Creek, in the Green Mountain area. Lost Soldier Creek is not within the project area. A majority (approximately 85 percent) of the Great Divide Basin drainage area within the project area drains internally, not leaving the project area. Approximately 10 percent of the Great Divide Basin drainage area within the project area receives run-on from other areas in the basin (Bear Creek, Red Creek, Lost Creek, and Stewart Creek to the north, and Smiley Draw to the west). Surface water from the remaining 5 percent of the project area in the Great Divide Basin drains to the east off the project area by way of Creston Draw, Buck Draw, and Fillmore Creek, which are tributaries to Separation Creek. Major surface water features within the Great Divide Basin associated with the project area are shown on **Map 3.4-2**.

3.4.2.1 Surface Water Location and Quantity

Detailed information regarding surface water quantity within the project area is provided in **Appendix F, Water Resources Supplemental Data.** Historic flow data are available near the project area from one station on Muddy Creek (U.S. Geological Survey [USGS] Station 09259000) and one station on the Little Snake River (USGS Station 09257000). Current flow data are available from one station, monitored between 2004 and the present, on Muddy Creek (USGS Station 09258980). Historic flow data in the Great Divide Basin are available near the project area from two stations on Separation Creek (USGS Stations 09216525 and 09216527). Although all five of these stations are outside of the project area, they represent the nearest USGS flow monitoring stations.

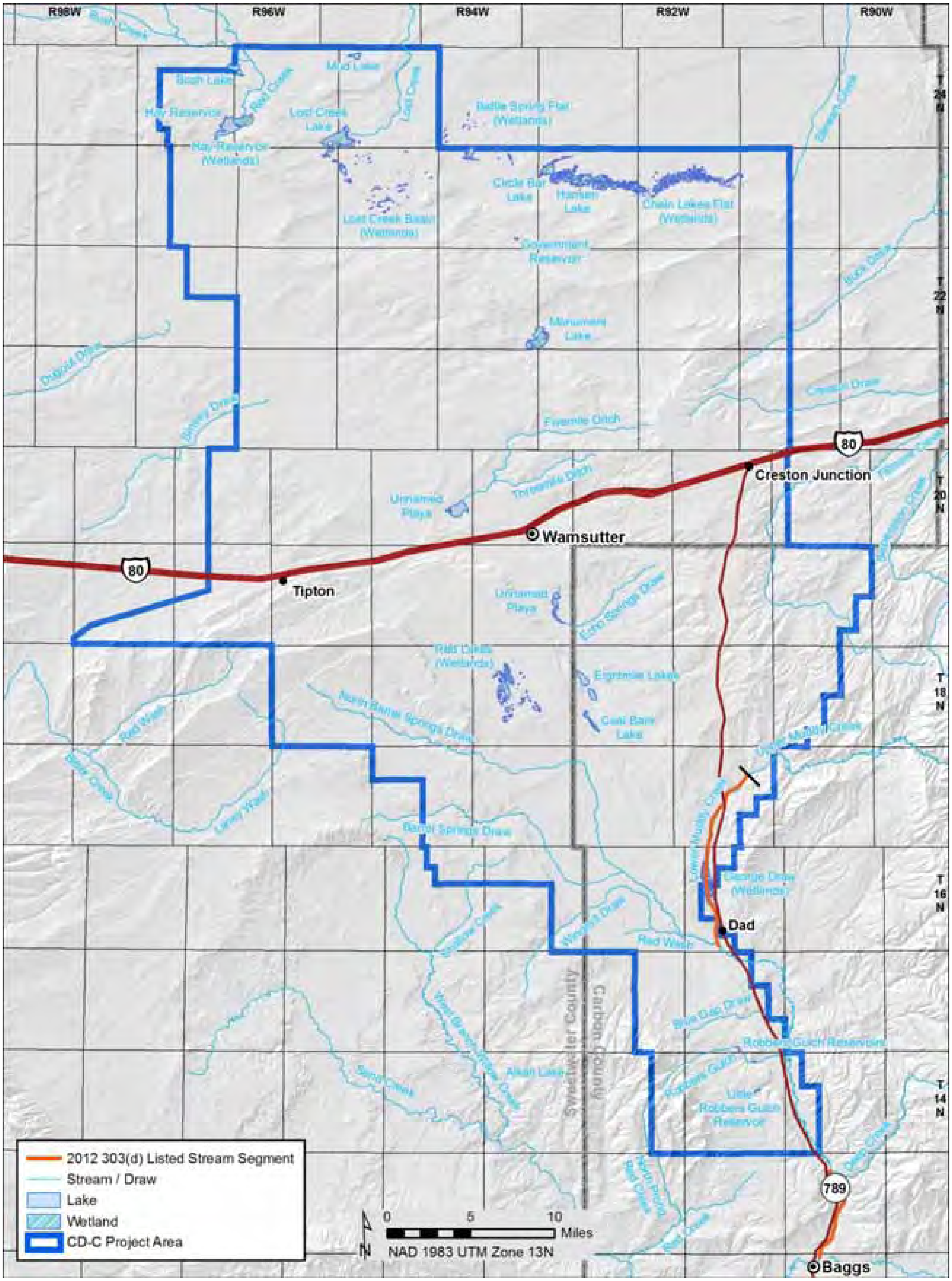
Upper Green Basin

A very small portion of the project area drains into the Upper Green Basin (**Map 3.4-1**). Less than one percent of the project area is drained by tributaries to Bitter Creek (HUC 14040105). Bitter Creek is a perennial stream that flows into the Green River approximately 50 miles west of the project area. Historical flow data (1975-1981) are available from one monitoring station on Bitter Creek (USGS Station 09216545). Flow data from this station varied widely, from zero to 333 cubic feet per second (cfs).

White-Yampa Basin

Approximately 29 percent of the project area is drained by the White-Yampa Basin (**Map 3.4-1**). Watersheds within the White-Yampa Basin that are associated with the project area include the Muddy Creek Sub-basin (HUC 14050004) and the Little Snake Sub-basin (HUC 14050003).

Muddy Creek begins in the Sierra Madre Range, east of the project area. Muddy Creek and its ephemeral tributaries, including Barrel Springs Draw (and its tributaries North Barrel Springs Draw and Windmill Draw), Blue Gap Draw, Robbers Gulch, and Red Wash, are included in this sub-basin. Muddy Creek flows west to Wyoming State Highway (WY) 789, where it enters the project area. It then flows south, meandering in and out of the project area, to its confluence with the Little Snake River near Baggs, Wyoming, approximately 6 miles south of the project area (**Map 3.4-1**). The Muddy Creek watershed encompasses approximately 1,200 square miles (mi^2) and ranges in elevation from about 6,300 to about 8,200 feet.



Map 3.4-2. CD-C project area surface water features

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Muddy Creek is a high-elevation, cold-desert stream. Streamflow varies with location along the drainage. Muddy Creek exhibits perennial flow for the majority of its length, and in some years flows intermittently because of irrigation water removal south of the George Dew/Red Wash wetlands complex. In years with high runoff amounts, Muddy Creek flows perennially throughout its length. Snowmelt (typically March to mid-June) produces significant runoff from higher elevations of the watershed, east of the project area. The intermittent stream flow that is present in some reaches below the George Dew/Red Wash wetlands complex is due to contributions from springs, seeps, and flowing wells. High-flow events can occur in response to precipitation events during the summer and fall months.

Flow in the tributaries to Muddy Creek is predominantly ephemeral, responding to localized snowmelt and rainfall events, but tributaries may also experience some intermittent flow due to contributions from springs and seeps. Tributary channels are generally dry and prone to flashy, periodic flood events from isolated thunderstorm systems from May to October.

Beatty (2005) divided Muddy Creek into two major segments: upper Muddy Creek and lower Muddy Creek (**Map 3.4-1**). The upper segment is identified as that portion of the watershed upstream of a large headcut stabilization structure that is located in Section 11, T17N: R92W. This structure is located just downstream of where Muddy Creek crosses the ARPA boundary and just upstream of where Muddy Creek crosses WY 789 (Map 3.4-1). The four primary tributaries mentioned above are within the lower segment, which extends from the large headcut stabilization structure to the Little Snake River confluence. Lower Muddy Creek is highly erosional and has abundant channel incisions (Beatty 2005). Channel substrates in the lower segment consist of very fine-grained sediments (sands, silts, and clays). A large wetland complex (George Dew/Red Wash) occurs on the reach of Muddy Creek that lies west of WY 789 (**Map 3.4-2**). This wetland area consists of impoundments, artificially constructed channels, vertical drop structures, headgate structures for water diversion, overflow spillways, and a braided stream-channel network.

The historical mean flow rates at two USGS Stations (09259000 and 09258980) on Muddy Creek near Baggs were 14.8 cubic feet per second (cfs) and 18.0 cfs, respectively. Calculated median flows at the same two stations were 2.8 cfs and 1.1 cfs (USGS 2011a). Median flows are generally more representative of the central tendency of the data because outliers (highest and lowest flow rates) can dramatically impact the average whereas the median is less affected. Because precipitation varies significantly from year to year, annual runoff values can vary significantly. Based on the 1,200 mi^2 drainage area and a 2004-2010 average annual runoff of 14,360 acre feet per year, the unit runoff for the Muddy Creek at USGS Station 09258980 is about 0.2 inch per year (USGS 2011a).

The Upper Muddy Creek Watershed/Grizzly Wildlife Habitat Management Area (Grizzly WHMA) is located primarily east of the CD-C project area (**Map 3.9**-5). The western-most portion of the Grizzly WHMA lies within the CD-C project area. The WHMA consists of 59,477 acres of public lands surface in a checkerboard pattern. The goal of the WHMA is to “manage habitat for the Colorado River fish species unique to the Muddy Creek watershed” (BLM 2008a). In the Grizzly WHMA, the WGFD has been working with the BLM, the grazing permittee, and the Little Snake River Conservation District (LSRCD) to implement similar measures. According to the Rawlins RMP, the area is open to oil and gas leasing with intensive management of surface-disturbing and disruptive activities (BLM 2008a).

Willow Creek/Shallow Creek (tributaries to Sand Creek) and the North Prong of Red Creek are drainages in the Little Snake Sub-basin that drain a small portion of the project area. Sand Creek and the North Prong of Red Creek flow into the Little Snake River approximately 8 miles from the southwest corner of the project area boundary (**Map 3.4-1**). Willow Creek/Shallow Creek and the North Prong of Red Creek are unclassified ephemeral drainages. No flow data are available for Willow Creek or the North Prong of Red Creek. The Little Snake River originates in the Sierra Madre Range and flows southwest into Colorado. The historical (1910–1923 and 1938–1971) mean flow rate at USGS Station 09259000 on the Little Snake River near Dixon was 514.3 cfs. Calculated median flow at the same station was 100.0 cfs

(USGS 2011a). Because precipitation varies significantly from year to year, annual runoff values can vary significantly. Based on the 988 mi^2 drainage area above USGS Station 0925700 and a 1911-1971 average annual runoff of 372,355 acre feet per year, the unit runoff for the Little Snake River at USGS Station 09257000 is about 7.1 inches per year (USGS 2011a).

Great Divide Basin

The northern 70 percent of the project area is within the Great Divide Basin, a closed basin that is bounded by the Continental Divide on all sides and has no surface hydrologic outlet (USGS 1976; Seaber et al. 1987). The Great Divide Basin is a relatively shallow depression with isolated buttes, pan-like depressions, and sparse vegetation. In general, streams within the Great Divide Basin are ephemeral, but can be intermittent in sections (Lowham et al. 1976). The only streams in the Great Divide Basin with perennial flow are the upper portion of Separation Creek, in the Atlantic Rim area and Lost Soldier Creek, in the Green Mountain area. Numerous ephemeral streams flow toward the center of the Basin and terminate in natural or artificially constructed impoundments or disappear due to losses to diversions, evaporation, and/or infiltration (seepage). There are some spring-fed systems such as the Battle Springs Flat and unique alkaline wetland systems around Chain Lakes. Since a majority of the project area is within the Great Divide basin and since it is a closed basin, a majority of the surface water flow originating in the CD-C project area terminates within the project boundary.

The Chain Lakes wetlands are located in the north central portion of the CD-C project area (**Map 3.4-2**). They are managed cooperatively by the WGFD and BLM as the Chain Lakes WHMA. The Chain Lakes WHMA consists of 30,560 acres of public lands in a checkerboard pattern. This area is one of the lowest topographic regions (6,500 feet in elevation) within the Great Divide Basin, resulting in numerous shallow lakes that are alkaline due to the lack of external water outlets. The annual precipitation of less than 7 inches, high evaporative loss rates, and surface salt crusting also contribute to shaping this community. The lakes and adjacent moist soils support a variety of plant and animal species adapted to this environment. The goal of the Chain Lakes WHMA is to "*manage the unique, fragile, and rare alkaline desert lake system and wildlife habitat values associated with the lake system*" (BLM 2008a). According to the approved Rawlins Resource Management Plan (RMP), the area is open to oil and gas leasing with intensive management of surface disturbing and disruptive activities (BLM 2008a).

While a majority of the surface water flow originating in the project area terminates within the project boundary, the majority of surface water leaving the project area in the Great Divide Basin flows into Separation Creek via Fillmore Creek and Creston Draw. Separation Creek flows adjacent to and east of the CD-C project area to Separation Lake. Separation Creek is, for most of its length, an ephemeral stream. It exhibits perennial flow in its upper reaches. Average flows documented at the two stations near Riner are 1.3 to 1.8 cfs. Estimated annual runoff volume for downstream reaches of Separation Creek is 2,500 acre-feet (Larson and Zimmerman 1981). Fillmore Creek is an ephemeral stream (WDEQ 2001) that flows only in response to snowmelt or rainstorms, with snowmelt as the biggest contributor. Springs provide minor flow in the upstream reaches.

Several other small ephemeral streams flow out of the project area but also have no outlets from the Great Divide Basin.

Reservoirs, Lakes, and Ponds

According to the Wyoming State Engineer's Office (SEO) database, there are 286 reservoirs with valid water rights within the project area (SEO 2011). Approximately 96 percent (274) of these water bodies have an appropriated use of stock. Major reservoirs within the CD-C project area are shown on **Map 3.4-2**. A complete list of valid surface-water rights associated with reservoirs, lakes, and ponds is included in **Appendix F, Water Resources Supplemental Data.**

Wetlands

Wetlands are aquatic features defined as "*those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas*" (33 CFR 328.3(b)). The prolonged presence of water creates conditions that favor the growth of specially adapted plants and promote the development of characteristic wetland (hydric) soils (EPA 2007). Vegetation in wetland environments is highly productive and diverse and provides habitat for many wildlife species. These systems as a whole play important roles in controlling floodwaters, recharging groundwater, and filtering pollutants (Niering 1985).

The U.S. Army Corps of Engineers (USACE) administers a regulatory program under Section 404 of the Clean Water Act (CWA), which requires a permit for the discharge of dredged or fill materials into Waters of the U.S. (WoUS), including jurisdictional wetlands. This regulatory program requires that an inventory of all WoUS, including wetlands, be performed; permits be acquired prior to dredging or filling jurisdictional wetlands; and impacts to jurisdictional wetlands and Other Waters of the U.S. (OWUS) be adequately mitigated.

Formal wetland delineations have not been confirmed by the USACE for the project area. A preliminary evaluation of potential wetlands within the project area was completed using National Wetland Inventory (NWI) mapping. According to the NWI mapping, prominent natural wetland systems are found near internally drained sub basins in the northern portion of the project area within the Great Divide Basin (Hay Reservoir area, Lost Creek Basin, Battle Springs Flat, and Chain Lakes Flat) and artificially constructed/enhanced wetlands occur along Muddy Creek (George Dew/Red Wash wetland complex) in the southern portion of the project area (**Map 3.4-2**). There are also a large number of small wetlands linked to natural or artificially constructed impoundments throughout the project area. The vegetation types associated with riparian/wetlands habitats are discussed in **Section 3.6.2.9**.

3.4.2.2 Surface Water Use

As of February 2011, the SEO had a total of 383 permitted surface water rights on record within and 1 mile adjacent to the project area (SEO 2011). Stock use was associated with 334 of the surface water rights. Surface water rights were also associated with irrigation (39), wetlands and fisheries (30), miscellaneous (13), reservoir supply (12), industrial/oil (10), domestic (7), temporary use (4), flow through non-consumptive (2), wildlife (2), flood control (1), recreation (1), and unspecified (1). The total for permitted uses exceeds the number of permitted surface water rights due to the fact that many of the surface water rights were permitted for multiple uses. A complete list of valid surface-water rights is included in **Appendix F.**

WDEQ classifies Wyoming surface water resources according to the water body's use designation. More detailed information regarding surface-water use classifications are presented in **Appendix F**.

Ten lakes and reservoirs within the project area are classified for use by WDEQ (**Map 3.4-2**). None of the lakes or reservoirs in the project area are classified for *outstanding value* (Class 1). The highest classification on lakes and reservoirs within the project area is *drinking water* (Class 2AB). One reservoir (Little Robbers Gulch Reservoir) is within this classification. The highest classification for five of the lakes/reservoirs is *fish consumption* (Class 3A). The highest use classification for the remaining four water bodies is *other aquatic life* (Class 3B).

Seventeen streams and springs within the project area and two near the project area are classified by the WDEQ. None of the streams in or near the project area are classified for *outstanding use* (Class 1). The Little Snake River, located near the project area, is classified for use as *drinking wate*r (2AB). The highest classification for two streams within or near the project area is *non-game fish* (2C). The highest classification for 14 of the 19 streams/springs is *other aquatic life* (Class 3B). The highest classification for the remaining two streams is for *non-aquatic life use* (Class 4B/C).

3.4.2.3 Surface Water Quality

In the arid high plains of southwestern Wyoming, surface-water quality, like stream flow, is variable both spatially and temporally. Perennial stream water is generally of better quality than that of the ephemeral and intermittent streams. The quality of runoff is largely dependent upon the amount of salts, sediments, and organic materials that accumulate in dry stream channels between periods of runoff. Factors that can govern the amount of buildup of these materials are a basin's physical characteristics, land uses, and season of the year. More detailed information regarding water quality is presented in **Appendix F**.

According to **Section 3.3 Soils**, the project area contains many types of topsoil that are saline or sodic. These soils, when eroded as a result of runoff events, can make salt available for dissolution into surface waters. Approximately 70 percent of the entire project area was rated as having slight water erosion potential, approximately 22 percent had moderate water erosion potential, and just over 4 percent had severe water erosion potential (the remaining 4 percent was not rated). Nearly 73 percent of existing project area disturbance is located on lands with slight water erosion potential, nearly 22 percent on lands with moderate water erosion potential, and 3 percent on lands with severe water erosion potential (the remaining 3 percent was not rated) (**Section 3.3.2 Soil Limitations**).

Various federal and state agencies (e.g., USGS, BLM, EPA, and WDEQ) have monitored surface-water quality in and around the project area. Surface water samples have been analyzed for physical and chemical properties, salinity, and major ions. From this pool of existing water quality data, representative surface-water quality data were selected for inclusion in this EIS based on selecting sites on significant surface water courses and the availability of multiple samples from a particular site. Surface water quality data were evaluated from ten water-quality monitoring stations. Detailed information regarding surface-water quality within the project area is provided in **Appendix F**.

Surface water quality information in the Upper Green and White-Yampa sub-basin is available near the project area from two stations on the Little Snake River (USGS Stations 09257000 and 09259050), four stations on Muddy Creek (USGS stations 09258900, 09258050, 09258980, and 09259000), one station on Lower Barrel Springs Draw (USGS Station 09216310), and one station on Bitter Creek (USGS Station 09216545). Six of the seven sampling stations in the Upper Green and White-Yampa sub-basin are outside of the project area but indicate water quality of streams leaving the project area. Historic surface-water quality data in the Great Divide Basin are available for Fillmore Creek (USGS Station 09219240), the Chain Lakes (Station 481), and Separation Creek (USGS Station 09216527). The first two sampling stations listed are within the project area. Separation Creek is adjacent to and east of the project area.

Baseline Water Quality Data

Baseline surface-water quality data at selected sites associated with the project area are presented in **Table 3.4-1**.

Table 3.4-1. Surface-water quality at selected sites associated with the CD-C project area

	Number of Samples[2]	Ph, Standard Units	Conductance, µmhos/cm (Mean)	Conductance, µmhos/cm (Min)	Conductance, µmhos/cm (Max)	TDS (Mean)	TDS (Minimum)	TDS (Maximum)	Suspended Solids[3] (Mean)	Suspended solids[3] (Minimum)	Suspended Solids[3] (Maximum)	Turbidity, NTU (Mean)	Calcium (Mean)	Magnesium (Mean)	Potassium (Mean)	Sodium (Mean)	Bicarbonate (Mean)	Sulfate (Mean)	Chloride (Mean)	Iron, µmhos/cm g/L (Mean)	Hardness ($CaCO_3$) (Mean)	Dissolved Oxygen (Mean)
Little Snake River (09257000)	107	8.1	259$_{(34)}$	82	460	158$_{(9)}$	46	260	154$_{(101)}$	4	1,180	13	30	8	2	11	159	25	3	74	111	9
Little Snake River (09259050)	100	8.1	366$_{(90)}$	87	855	243$_{(17)}$	87	540	228$_{(25)}$	6	852	167	34	12	2	26	190	54	2	164	151	10
Muddy Creek [1] (09258050)	19	8.2	879$_{(15)}$	570	1,170	1,460	395	897	256$_{(12)}$	12	1,370	56	95	39	4	43	nm	270	10	1,460	399	9.2
Muddy Creek (09258900)	3	8.6	1,350$_{(2)}$	600	2,100	913$_{(2)}$	396	1,430	6,198$_{(2)}$	195	12,200	1,260	54	44	7	200	373	380	65	105	315	11
Muddy Creek (09259000)	41	8.2	966$_{(35)}$	529	1,790	346$_{(1)}$	346	346	3,191$_{(41)}$	7	22,500	nm	42	40	9	286	308	320	32	nm	270	10
Muddy Creek [1] (09258980)	76	8.3	1,763$_{(76)}$	448	3,990	1,229$_{(65)}$	267	2,810	324$_{(62)}$	13	2,530	55	82	53	5	257	nm	516	115	30	422	10
Lower Barrel Springs Draw (09216310)	7	8.4	533$_{(4)}$	340	1,000	619$_{(1)}$	619	619	nm	nm	nm	17	28	2	5	205	500	100	12	nm	80	5.2
Bitter Creek (09216545)	155	8.4	1,755$_{(149)}$	280	4,500	1,289$_{(78)}$	295	2,740	1,843$_{(105)}$	22	21,900	305	40	27	3	348	369	590	39	103	211	9.7
Upper Fillmore Creek (09219240)	1	7.7	700$_{(1)}$	700	700	495$_{(1)}$	495	495	141$_{(1)}$	141	141	984	32	68	7	22	68	320	12	210	nm	5
Separation Creek (09216527)	45	8.2	1,089$_{(39)}$	220	2,390	200$_{(1)}$	200	200	490$_{(1)}$	490	490	131	74	69	6	80	277	385	13	76	467	8.2
Chain Lakes, Hansen Lake (481)	15	9.1	4,502$_{(7)}$	1,800	11,350	4,465$_{(8)}$	1,304	11,289	423	15	956	nm	13	8	13	1,604	1,400	1,139	342	17,090	67	6.4

[1] Daily mean values analyzed through February 14, 2012.
[2] Total number of grab samples analyzed; not every parameter was analyzed in every sample.
[3] Total concentration; except as noted here, all reported values represent dissolved concentrations.

NTU = Nephelometric Turbidity Units.

nm = Not measured.
(34) - Number of samples analyzed for that parameter.
All units are mg/L except as noted.

Source: WRDS 2007, USGS 2012

Surface water quality information in the Muddy Creek watershed was examined for this EIS at Muddy Creek (USGS Stations 09258050, 09258980, 09259000, and 09259050 stations) and Lower Barrel Springs Draw (USGS Station 09216310). The water quality was variable both spatially and temporally. Muddy Creek water quality was characterized by moderate conductance and total dissolved solids (TDS) concentrations. The predominant ions were sodium, sulfate, and bicarbonate. Lower Barrel Springs Draw had moderate conductance and TDS values.

Water quality in the Little Snake River was characterized (based on analysis at USGS Stations 09257000 and 09259050) by low conductance and TDS concentrations. The water type was calcium bicarbonate.

Water quality in the Bitter Creek watershed (based on analysis at USGS Station 09216545) was variable. Conductance and TDS values for Bitter Creek tended to be higher than those levels seen at the other stations.

Water quality in the Great Divide Basin was examined at three stations. Upper Fillmore Creek (USGS Station 09219240) had low conductance and TDS levels. Separation Creek (USGS Station 09216527) had variable conductance. TDS concentrations in Separation Creek were low. The Chain Lakes/Hansen Lake (WDEQ 481) had high conductance and high TDS levels.

Surface waters associated with the project area had moderately to highly basic pH (7.7 to 9.1). Dissolved oxygen concentrations were moderate (5.2 to 11). Hardness values varied between soft in the Chain Lakes (67 mg/L $CaCO_3$) to hard in Separation Creek (467 mg/L $CaCO_3$). Alkalinity (as expressed as bicarbonate) varied from 68 mg/L in upper Fillmore Creek to 1,400 mg/L in Chain Lakes.

Suspended solids concentrations were typically high in Muddy Creek and Bitter Creek. Suspended sediment concentrations, like TDS concentrations, were greater in the ephemeral and intermittent streams than the perennial Little Snake River. The mean suspended solid concentrations in the Great Divide Basin ranged between 141 mg/L (Upper Fillmore Creek) and 490 mg/L (Separation Creek).

Turbidity values were consistent with the suspended solids concentrations. Muddy Creek and Bitter Creek had turbidity of up to 1,260 and 305 nephelometric turbidity units (NTUs). The Little Snake River showed turbidity of up to 167 NTUs. Lower Barrel Springs Draw and Upper Fillmore Creek showed turbidity less than 100 NTUs. Turbidity at Separation Creek was 131 NTUs.

The ionic composition of the various surface water bodies associated with the project area was variable. Major ion characterization of each surface water sample was compared. Bicarbonate was the dominant anion (negatively charged ion) in the Little Snake River, Lower Barrel Springs Draw, and the Chain Lakes. Sulfate was the dominant anion in Muddy Creek, Bitter Creek, Upper Fillmore Creek, and Separation Creek. Chloride was not dominant in any of the samples. Calcium was the dominant cation (positively charged ion) in the Little Snake River. Sodium was the dominant cation in Muddy Creek, Lower Barrel Springs, Bitter Creek, the Chain Lakes, and Separation Creek. Magnesium was high in Upper Fillmore Creek.

Irrigation suitability of the streams as a function of sodium-adsorption ratio and salinity was examined for each stream sample. The Little Snake River, Muddy Creek, Lower Barrel Springs Draw, and Upper Fillmore Creek are in the C1-S2 category. C1-S2-categorized water can be used for all crops and soils where salt toxicity is concerned; however, the sodium may cause clay particles in irrigated soils to swell and disperse and thereby reduce the soil infiltration rate. Bitter Creek and Separation Creek are in the C2-S1 category. C2-S1 water should be used with caution on moderately salt tolerant crops and should not be used on salt sensitive crops. Water from the Chain Lakes is categorized as C3-S2 water, indicating that crop production would suffer greatly if it were used for irrigation.

Based on average values, Muddy Creek was moderately suitable as an irrigation-water supply where flows are available. The George Dew/Red Wash wetland complex is the primary location where Muddy Creek is used for irrigation (the wetland complex is formed by spreader dikes along Muddy Creek) (**Maps**

3.4-2 and **3.9-5**). This area is primarily used for cattle and there is a diversion for small-scale bottomland irrigation along Muddy Creek.

Salinity has become a major concern within the Colorado River drainage basin. The 1972 Clean Water Act required the establishment of numeric criteria for salinity for the Colorado River and in 1973, seven Colorado River basin states created the Colorado River Basin Salinity Control Forum. The Forum developed water quality standards for salinity including numeric criteria and a basin-wide plan of implementation. The plan consists of a number of control measures to be implemented by State and Federal agencies. In 1974, Congress enacted the Colorado River Basin Salinity Control Act. The Act was amended in 1984 to require the Secretary of Interior to develop a comprehensive program to minimize contributions from lands administered by the BLM.

Selenium, like mercury and other metals, bioaccumulates in organisms at each trophic level. Aquatic life is exposed to selenium primarily through diet. Unlike mercury or PCBs, concentrations of selenium do not increase significantly in animals at each level of the food chain going from prey to predator (EPA 2011b). The core regulatory guidelines for aquatic selenium pollution in the United States are the Aquatic Life Water Quality Criteria (Aquatic Life Criteria) derived by the U.S. Environmental Protection Agency (EPA) pursuant to the Clean Water Act (CWA) of 1977. The current aquatic life chronic criterion for selenium set by the EPA and WDEQ is 5 µg/L (EPA 2011b and WDEQ 2001).

3.4.2.4 Water Bodies with Impairments or Threats

The WDEQ evaluates streams periodically to determine what streams are threatened or impaired relative to the use classification. The current threatened and impaired streams are listed in Wyoming's 2012 305(b) Water Quality Assessment Report (WDEQ 2012). According to the assessment report, a portion of Muddy Creek (west of WY 789) is listed as threatened. No other surface water bodies in the project area are listed as threatened or impaired, although one other segment of Muddy Creek outside of the project area is listed as impaired due to exceedances of chloride and selenium criteria.

According to WDEQ (2012), "*Unstable stream channels and loss of riparian function have been identified as problems in much of the Muddy Creek Sub-basin*," in reference to Muddy Creek. The LSRCD, working through a Coordinated Resource Management (CRM) process with the BLM, landowners, grazing permittees, WGFD, and other stakeholders, addressed these water quality and riparian habitat problems. As part of the CRM process, LSRCD managed several Section 319 watershed improvement projects in the upper Muddy Creek drainage. Implementation measures included upland water development, cross fencing, and vegetation and grazing management. While the CRM process is no longer formally in place, the beneficial effects are still being realized.

Within the project area, several projects have been designed for Muddy Creek to address physical (riparian condition and bank stability) degradation of the stream channel, which threatens its aquatic life support. Upstream of the project area reclamation measures included planting a variety of woody riparian vegetation to help stabilize streambanks, removal of a culvert on Muddy Creek, and restoration of 0.75 mile of Muddy Creek in the upper watershed. According to WDEQ, results of this project showed considerable improvement to stream stability, aquatic habitat and riparian health, especially in the upper Muddy Creek tributaries (WDEQ 2012).

Habitat degradation has been identified by the BLM and LSRCD as a serious water-quality concern on Muddy Creek from Red Wash (in the project area) downstream to the Little Snake River. According to WDEQ (2012), habitat degradation is likely caused by season-long riparian grazing that is exacerbated by accelerated erosion associated with oil and gas activities. WDEQ (2012) also states, "… *projected increases in CBM [CBNG] development may lead to increased surface disturbance and increased erosion and sediment loading.*" Several grazing management BMPs are being implemented in much of this lower watershed including changes in length, timing and duration of grazing, and cross-fencing. The Upper Muddy Creek Watershed/Grizzly WHMA is located in the north central portion of the CD-C project area. This WHMA was established with the goal to "manage habitat for the Colorado River fish species unique to the Muddy Creek watershed" (BLM 2008a). In the Grizzly WHMA, the WGFD has been working with the BLM, the grazing permittee, and the LSRCD to implement similar measures.

3.4.2.5 Salinity Issues in the Colorado River Basin

The southern 30 percent of the project area is located in the Colorado River Basin; as such, point-source discharge permits are regulated by the State of Wyoming in accordance with its adoption and incorporation into the Water Quality Rules and Regulations of the Colorado River Basin Salinity Control Forum (CRBSCF), which was established in 1973 (CRBSCF 2008). The CRBSCF is composed of representatives from each of the seven Basin states appointed by the governors of the respective states. The CRBSCF was created for interstate cooperation and to provide the states with the information necessary to comply with Section 303(a) and (b) of the Clean Water Act. In 1975, CRBSCF proposed, the states adopted, and the EPA approved water quality standards which included numeric criteria and a plan of implementation to control salinity increases in the Colorado River. The plan was designed to maintain the flow-weighted average annual salinity concentrations at or below the 1972 levels, while the Basin states continued to develop their compact-apportioned water supply (CRBSCF 2008).

According to the CRBSCF, the focus for the implementation of salinity standards in the National Pollutant Discharge Elimination System (NPDES) permit program policy "*shall be a no-salt return policy whenever practicable.*" The NPDES Program policy (revised in 2002) states that the permitting authority may permit the discharge of salt from new industrial sources upon a satisfactory demonstration by the permittee that salt loading to the Colorado River from the new construction is less than one ton per day or 366 tons per year, or the proposed discharge from the new construction is of sufficient quality in terms of TDS concentrations that the maximum TDS concentration is 500 mg/L for discharges into the Colorado River and its tributaries upstream of Lees Ferry, Arizona (CRBSCF 2008). In general, the salinity concentrations have decreased at the monitoring stations since the program was implemented (CRBSCF 2008).

As one of the seven member states of the CRBSCF, Wyoming regulates point discharge sources of salinity in the Wyoming portion of the Colorado River Basin through its Wyoming Pollutant Discharge Elimination System (WYPDES) permit program. The program is administered by the WDEQ/Water Quality Division (WQD) (WDEQ 1982).

3.4.3 Groundwater

The project area occurs in the Colorado Plateau and Wyoming Basin groundwater regions described by Heath (1984) and the Upper Colorado River Basin groundwater region described by Freethey (1987). More specifically, the project area is located over the Great Divide and Washakie structural basins in eastern Sweetwater and southwestern Carbon counties. The northern half of the project area is occupied by the Great Divide Basin and the southern half of the area is occupied by the Washakie Basin, with the Wamsutter Arch separating the two structural basins. Relatively recent studies by the USGS (Mason and Miller 2005; Bartos *et al.* 2006;) cataloged the groundwater resources within Sweetwater and Carbon counties, which include the Great Divide and Washakie structural basins. Groundwater resources include deep and shallow, confined and unconfined aquifers. Groundwater occurrence and flow in the project area are controlled largely by the geologic structure and precipitation in the area. Most of the saturated geologic units in the project area are heterogeneous, consisting of aquifers, semi-confining units, and confining layers.

3.4.3.1 Groundwater Location and Quantity

Welder and McGreevy (1966) reported that the geologic formations capable of producing the greatest quantities of water in the project area include the following: Quaternary alluvium; Tertiary deposits in the Wasatch and Fort Union Formations; Cretaceous units, including the Mesaverde Group and the Frontier and Cloverly Formations; the Sundance-Nugget Sandstone of the Jurassic age; and the Tensleep and

Madison Formations of the Paleozoic Era (**Figure 3.1-1, Section 3.1.2**). General aquifer characteristics are provided in **Appendix F**. Fisk (1967) estimated that the amount of moderately good-quality groundwater within the Great Divide Structural Basin was 500 million ac-ft and 300 million ac-ft. within the Washakie Structural Basin. The available data are not adequate for estimating the quantities of groundwater stored within the individual hydrogeologic units or the aquifer systems in the Green River Watershed Basin, which includes the Great Divide and the Washakie structural basins, but estimates of producible water volumes are available for the Tertiary formation beneath the Greater Green River Basin (Cleary *et al.* 2010).

Quaternary aquifers in the Great Divide and Washakie basins are comprised of alluvial deposits along floodplains and isolated wind-blown and lake sediments. The Quaternary aquifers in the vicinity of the project area occur in alluvial deposits along Muddy Creek (Washakie Basin), in the Red Desert Flats area and around lakes (Great Divide Basin), and in wind-blown segments in the northwest and southeast of the project area. Groundwater flow within the sandy Quaternary aquifers is typically downward toward permeable underlying formations (Collentine *et al.* 1981). Intermittent drainages also often contain groundwater in the associated unconsolidated valley fills. Incised drainages serve as capture areas for wind-blown sand in reaches perpendicular to the prevailing winds. The sand-choked drainages favor rapid infiltration of rainfall and snowmelt, leading to contact springs and seeps where groundwater, perched in sandy surface deposits, escapes along contacts with less permeable bedrock. Thicknesses of Quaternary sediments range from zero to 70 feet. Well yields are typically less than 20 gallons per minute (gpm) (Welder and McGreevy 1966).

“Minor” Tertiary aquifers in the project area occur in the Laney Member of the Green River Formation (mostly in the Washakie Structural Basin). “Major” Tertiary aquifers in the project area include the Wasatch, Battle Springs, and Fort Union (Washakie and Great Divide basins). Using nomenclature of Collentine et al. (1981), “minor” and “major” aquifers are characterized based on their relative water-bearing potential. Aquifers near the surface are recharged from direct downward percolation of precipitation and snowmelt and from seepage losses from streams. Deep aquifers are also recharged by these processes in outcrop and subcrop areas and from slow leakage from overlying and underlying aquifers. Thicknesses of Tertiary deposits vary from zero to more than 4,000 feet. Wasatch Formation wells yield up to 50 gpm. The Laney Member of the Green River Formation and the Battle Springs and Fort Union formations can yield hundreds of gpm to wells (Mason and Miller 2005; Bartos *et al.* 2006). There are six wells that are designated as municipal use and supply a public water system completed in Tertiary age aquifers (all in the Wasatch Formation) within the project area. These six wells are associated with water supply for the Town of Wamsutter. Using estimates of the volume of producible groundwater from Cleary *et al.* (2010), the volume of groundwater in the top 1,000 feet of the Tertiary formation under the project area is approximately 9.67 million ac-ft. Fisk (1967) estimated that the amount of moderately good-quality groundwater within the Great Divide Structural Basin was 500 million ac-ft and 300 million ac-ft. within the Washakie Structural Basin.

Upper Cretaceous aquifers include “minor” aquifers in the Lance and Fox Hills formations. “Major” aquifers of this period include the formations within the Mesaverde Group (Almond Formation, Ericson Formation, Rock Springs Formation, and Blair Formation in descending order), the Baxter Shale, and the Frontier Formation. The Mesaverde Group contains “major” aquifer units (the Almond Formation, Pine Ridge Sandstone, Allen Ridge Formation, and Haystack Mountains Formation), and is referred to as the Mesaverde Aquifer (Mason and Miller 2005; Bartos *et al.* 2006) in the Washakie and Great Divide basins. Due to water-quality variability, it is considered a groundwater source only near outcrop areas. Units within the Mesaverde Group yield natural gas to conventional gas wells in the area. In the Atlantic Rim area to the east, coal seams within the Almond Formation are the target of CBNG development. In areas where they occur, Upper Cretaceous strata range from a few hundred feet to 5,000 feet thick. Well yields from the “minor” aquifers are typically less than 25 gpm. Well yields of up to several hundred gpm are reported for the “major” aquifers (Welder and McGreevy 1966).

The Lower Cretaceous aquifers generally are deeply buried in the center of the Great Divide and Washakie basins, though these formations outcrop near the eastern edge of the project area. The lower Cretaceous strata consist of shale layers that act as regional aquitards or leaky confining layers (Mowry and Thermopolis shales). The Cloverly Formation is a “major” aquifer. Yields to wells range from 45 to 240 gpm (Mason and Miller 2005; Bartos *et al.* 2006). There are no wells that are designated as a domestic use or as a municipal use and supply a public water system completed in Lower Cretaceous aquifers within the project area.

The low-permeability Morrison Formation separates the Sundance-Nugget Aquifer of the Jurassic age from the Upper Cretaceous aquifers. The Jurassic-age Sundance-Nugget aquifer is comprised of permeable sandstone with minor quantities of shale, siltstone, and limestone (Collentine *et al.* 1981). The flow characteristics of the Sundance-Nugget aquifer are not well-defined. These aquifer units range from about 200 to 450 feet thick. Well yields are less than 35 gpm in the Sundance aquifer and up to 200 gpm in the Nugget aquifer (Mason and Miller 2005; Bartos *et al.* 2006). There are no wells that are designated as a domestic use or as a municipal use and supply a public water system completed in Sundance or Nugget aquifers within the project area.

According to Collentine *et al.* (1981), two “important water-bearing intervals” occur in Paleozoic-Era rocks within the project area. The Pennsylvanian age Tensleep Formation consists of fine- to medium-grained sandstone between confining layers of the Chugwater Formation (Triassic) and the Amsden Formation (Pennsylvanian) (Collentine *et al.* 1981). The Madison aquifer is comprised of limestone and dolomite bordered on the top by the fine-grained Amsden Formation and on the bottom by Cambrian rocks. Early Paleozoic rocks are notably absent from far southeast Wyoming and extremely thin on the west flank of the Sierra Madre uplift east of the project area. The zero isopach line for these Paleozoic units lies across and north of the Sierra Madre uplift indicating either non-deposition or erosion and complete removal of these units across the ancestral uplift prior to deposition of Mesozoic and Cenozoic age rocks. The truncated edge of Cambrian and Mississippian rocks lies east of the project area according to Blackstone (1963). Wells completed in the vicinity of the project area within both of these Paleozoic age aquifers, where present and of significant thickness, have demonstrated yields up to 400 gpm. There are no wells that are designated as a domestic use or as a municipal use and supply a public water system completed in Tensleep or Madison aquifers within the project area.

3.4.3.2 Groundwater Use

The SEO water rights database indicates that there are 1,081 groundwater wells permitted within or 1 mile adjacent to the project area (SEO 2011). Permitted well uses include stock (294), miscellaneous (218), domestic (80), industrial (18), municipal (6), irrigation (5), and test wells (1). The total for permitted uses exceeds the number of well permits due to the fact that many of the wells are permitted for multiple uses. A complete list of valid groundwater rights is included in **Appendix F**.

Other than designated land uses described above, little information is available on groundwater use specific to the Great Divide and Washakie structural basins. In 1981, total groundwater use in the Great Divide and Washakie basins was estimated by Collentine *et al.* (1981) at between 20,000 and 24,000 acre-feet per year, approximately 30 percent of the total water use. More recent estimates of groundwater use are available on a county-wide basis. In 2000, Sweetwater County groundwater use was estimated at 57,000 acre-feet per year, approximately 30 percent of the overall water used (Mason and Miller 2005). In 2000, Carbon County groundwater use was estimated at 7,000 acre-feet per year, less than 2 percent of the overall water used (Bartos *et al.* 2006).

3.4.3.3 Groundwater Recharge and Discharge

Recharge to aquifers in the project area occurs by infiltration of precipitation on outcrop areas, infiltration of snowmelt runoff from the mountains, and seepage from streams and lakes.

Four major groundwater-recharge areas are identified in the Great Divide and Washakie structural basins. Three of these areas are outside of the project area near Rock Springs in Sweetwater County and the Atlantic Rim area in Carbon County. The fourth recharge area is the topographic high area around Creston Junction (**Map 3.4-1**). Piezometric levels in hydrogeologic units are higher in these four major recharge areas than other parts of the basin, probably because the higher altitude of these features results in slightly higher annual precipitation. Welder and McGreevy (1966) reported that most streams in the Washakie basin are “losing” streams, contributing to local groundwater recharge in the basin. The same is likely true for streams in the Great Divide Basin. Fisk (1967) estimated that the combined annual recharge for the Great Divide and Washakie structural basins was at 11,300 ac-ft. Section 4.9.3.1, Special Status Species, Proposed Action, includes a discussion of potential annual depletions to the Colorado River System.

Aquifers in the Great Divide and Washakie structural basins are reported to be in direct hydraulic connection across the Wamsutter Arch. Recharge is reported to be at least 15 cfs in both basins. Due to the large groundwater storage capacity and the low recharge rate, estimates indicate that it would take more than 50,000 years to refill the fresh-water aquifers of the basins with groundwater if all of the groundwater was removed (Mason and Miller 2005; Bartos *et al.* 2006).

In general, groundwater discharge from the aquifers throughout the project area occurs through seepage to streams and springs, discharge to wells, evaporation, and underground flow (Mason and Miller 2005; Bartos *et al.* 2006). According to Mason and Miller (2005), groundwater from the Mesaverde formation discharges to the Little Snake River, downstream of the confluence with Muddy Creek. Much of the deeper groundwater in the basins is artesian (i.e., having a static water level which rises to an elevation above the saturated zone). This results because the major recharge areas in the basins are exposed at higher elevations, putting the confined groundwater under hydraulic pressure. Water in a confined aquifer that is under hydraulic pressure will rise above the top of the aquifer when the overlying confining bed is pierced or broken, resulting in discharge from the confined aquifer (Mason and Miller 2005). The source of some of the water within the Chain Lakes surface water features in the Great Divide Basin is thought to be artesian groundwater that flows at the surface (WGFD 2008).

3.4.3.4 Groundwater Flow Direction

As discussed in Section 3.4.3.1, formations capable of producing the greatest quantity of water in the project area include the Quaternary alluvium, Tertiary deposits in the Wasatch and Fort Union Formations, Cretaceous units, including the Mesaverde Group and the Frontier and Cloverly Formations, the Sundance-Nugget Sandstone of the Jurassic age, and the Tensleep and Madison Formations of the Paleozoic Era. More detailed information regarding potentiometric surfaces of project area aquifers and groundwater flow are presented in **Appendix F**.

The Quaternary aquifers consist of unconsolidated sand and gravel formations, mainly of alluvial origin, interbedded with lake and wind-blown sediments. The Quaternary alluvium is highly permeable, absorbing rainfall and stream flow, transmitting it downward to underlying formations.

The groundwater flow direction in the Tertiary-aged Wasatch aquifer is from areas of recharge toward the basin center. In the Great Divide Structural Basin, Wasatch aquifer groundwater flows from the northwest, northeast, southwest, and southeast. In the Washakie Structural Basin, groundwater generally flows from west to east in the southern part of the Washakie Structural Basin. In the northern portion of the Washakie Basin groundwater motion is largely static. Some groundwater flows westward from the Washakie Structural Basin along Bitter Creek and southward along Muddy Creek.

Groundwater flow direction for the Upper Cretaceous-aged aquifer within the Mesaverde Group is undefined in the northern part of the Great Divide Structural Basin. Groundwater within the aquifers of the Mesaverde Group is reported to flow from the Great Divide Basin toward the east, southeast, southwest, and west. In the Washakie Structural Basin, groundwater is reported to flow to the west and south (Mason and Miller 2005; Bartos *et al.* 2006).

Available potentiometric data are sporadic and could not be used to delineate flow patterns in the Sundance-Nugget aquifer. Potentiometric heads are highest in the uplift areas to the east, west, north, and northeast (Collentine *et al.* 1981).

The groundwater flow direction for the Paleozoic-aged Tensleep aquifer is generally from the recharge areas along the northern and eastern flanks of the Great Divide Basin. Additional recharge into the Washakie Basin may occur to the south and east of the Rock Springs uplift. Tensleep aquifer groundwater flow is from the recharge areas toward the basin centers (Collentine et al. 1981). The groundwater flow direction for the Paleozoic-aged Madison aquifer is generally west, away from the outcrops (sources of recharge) towards the Great Divide and Washakie basin centers (Bartos *et al.* 2006).

3.4.3.5 Groundwater Quality

For the most part, comparisons between groundwater quality within the different structural features in the project area are difficult given the large variation in water quality within the features. In general, the quality of the groundwater underlying the Great Divide and Washakie basins is largely related to the depth of the aquifer, the type of strata in the saturated zone, the recharge rate and volume at the area sampled, and the residence time of the groundwater in the aquifer. Typically, quality of groundwater within a given hydrogeologic unit usually deteriorates with depth.

Water-quality samples collected from wells and springs within Quaternary and Tertiary hydrogeologic units that were being used to supply water for livestock and wildlife were typically of good water quality (i.e. fresh water, see below). Wells that do not produce usable water are usually abandoned, and springs that do not produce usable water typically are not developed. In addition, where hydrogeologic units are deeply buried, they usually are not tapped for a water supply when a shallower supply is available. For these reasons the groundwater quality samples from the Quaternary and Tertiary hydrogeologic units are most likely biased toward better water quality and do not represent a random sampling of the units. Although the possible bias of these data does not allow for a complete characterization of the water quality of these hydrogeologic units as a whole, it probably allows for a more accurate characterization of the units in areas where they are shallow enough to be economically used.

Most of the groundwater-quality samples used to characterize Mesozoic and Paleozoic hydrogeologic units came from the USGS Produced Waters Database (USGS 2011b). Although these samples were collected only where oil and gas production has taken place, they probably have less bias in representing ambient groundwater quality within hydrogeologic units developed as a result of this project than samples used to characterize Quaternary and Tertiary hydrogeologic units.

Baseline groundwater-quality data (TDS and selenium) at selected aquifers associated with the project area are presented in **Table 3.4-2**. More detailed data regarding groundwater quality are presented in **Appendix F**.

TDS concentrations in ground-water samples are classified according to the USGS salinity classification (Heath 1983) as follows: fresh, 0-1,000 mg/L; slightly saline, 1,000-3,000 mg/L; moderately saline, 3,000-10,000 mg/L; very saline, 10,000-35,000 mg/L; and briny, more than 35,000 mg/L.

TDS values for 18 samples collected in Quaternary aquifers in Sweetwater County ranged from fresh to very saline with the median value within the slightly saline range. In Carbon County, 32 samples collected from Quaternary aquifers varied from fresh to moderately saline with the median value within fresh range.

Table 3.4-2. Groundwater quality parameters for selected aquifers associated with the CD-C project area

	From Mason and Miller (2005)					From Bartos *et al.* 2006						Produced Water		
	Sweetwater Co. Quaternary Aquifer	Sweetwater Co. Wasatch Aquifer	Sweetwater Co. Mesaverde Aquifer	Sweetwater Co. Nugget Aquifer	Sweetwater Co. Madison Aquifer	Carbon Co. Quaternary Aquifer	Carbon Co. Wasatch Aquifer	Carbon Co. Mesaverde Aquifer	Carbon Co. Nugget Aquifer	Carbon Co. Madison Aquifer	Sweetwater Co. Wasatch/Ft. Union Aquifer Produced Water	Sweetwater Co. Mesaverde Aquifer Produced Water	Sweetwater Co. Nugget Aquifer Produced Water	Madison Aquifer (USGS 2011b)
# of Samples	18	80	30	--	17	32	11	130	15	11	--	221	28	2
Parameter														
TDS (Median) (mg/L)	1,200	1,000	1,000	--	11,100	500	2,000	5,000	4,500	3,000	13,900	12,000	10,000	30,300
TDS (Min) (mg/L)	500	150	200	3,000	3,820	30	700	250	1,500	150	1,050	2,800	5,000	6,094
TDS (Max) (mg/L)	20,000	8,000	20,000	35,000	76,800	8,000	5,000	40,000	50,000	12,000	153,000	65,000	40,000	54,545
Selenium (Median) (µg/L)	32.9[1]	0.7[2]	nm[7]	<1[3]	nm	3.9[4]	0.6[5]	0.6[6]	nm	1.4[3]	nm	nm	nm	nm
Selenium (Min) (µg/L)	3.8[1]	0.3[2]	nm	<1[3]	nm	<0.5[4]	0.4[5]	<0.3[6]	nm	1.4[3]	nm	nm	nm	nm
Selenium (Max) (µg/L)	133[1]	1.6[2]	nm	<1[3]	nm	4.5[4]	<0.7[5]	0.8[6]	nm	1.4[3]	nm	nm	nm	nm

[1] *Based on 7 Samples*
[2] *Based on 8 Samples*
[3] *Based on 1 Sample*
[4] *Based on 3 Samples*
[5] *Based on 4 Samples*
[6] *Based on 6 Samples*
[7] *Not Measured.*

TDS concentrations from 80 samples collected from the Wasatch aquifer (Tertiary age) in Sweetwater County ranged from fresh to moderately saline, with a median value within the fresh/slightly saline range. TDS values for 11 samples collected in Carbon County ranged from fresh to moderately saline, with a median value within the slightly saline range. TDS values from samples collected in Sweetwater County of water produced by oil and gas extraction from the Wasatch/Fort Union formations ranged from slightly saline to briny. TDS values of produced water from the Wasatch aquifer above 60,000 mg/L occurred at depths greater than about 2,500 feet below ground surface (Mason and Miller 2005).

TDS concentrations in 30 samples collected in Sweetwater County from the aquifers of the Mesaverde group ranged from fresh to very saline, with a median value within the fresh/slightly saline range. TDS from 130 samples collected in Carbon County from the aquifers of the Mesaverde Group ranged from fresh to briny. TDS in 221 samples of water from oil and gas production in the Mesaverde ranged from slightly saline to briny with a median value within the very saline range.

TDS concentrations from samples collected from the Nugget aquifer in Sweetwater County ranged from slightly/moderately saline to very saline/briny. TDS values for 15 samples collected in Carbon County ranged from slightly saline to briny, with a median value within the moderately saline range. TDS values from 28 samples collected in Sweetwater County of water produced by oil and gas extraction from the Nugget formation ranged from moderately saline to briny.

TDS concentrations from 17 samples collected from the Madison aquifer in Sweetwater County ranged from moderately saline to briny, with a median value within the very saline range. TDS values for 11 samples collected in Carbon County ranged from fresh to very saline, with a median value within the slightly/moderately saline range. TDS values from samples collected in Sweetwater County of water produced by oil and gas extraction from the Madison Formation ranged from moderately saline to briny.

In general, TDS concentrations typically increase with the depth below ground surface. TDS values are usually higher when the aquifer is interbedded with lake or marine deposits that contain evaporate minerals.

Selenium values obtained from samples of selected aquifers are included in **Table 3.4-2**. In comparison to the number of samples analyzed for TDS, selenium sampling results are sparse but they do provide some idea of the potential for encountering excessive selenium in produced water. EPA's current chronic criterion for selenium is 5 μg/L (EPA 2011a). WDEQ/LQD's groundwater fish/aquatic life use suitability limit for selenium is also 5 μg/L (WDEQ/LQD 2005). Both the EPA's chronic criterion and WDEQ-WQD's suitability limits for selenium were exceeded in Quaternary aquifer water samples.

Confining beds typically restrict the movement of groundwater between aquifers, hence, movement of potential contaminants between aquifers. Although there is some downward movement of the water from the shallow surficial units, most of the groundwater movement, if any, is upward from the deeper confined aquifers to the shallower unconfined aquifers. Water in a confined aquifer is under hydraulic pressure and will rise above the top of the aquifer when the overlying confining bed is pierced or broken (Mason and Miller 2005). There is potential for groundwater quality degradation due to the piercing of confining layers and vertical and horizontal migration and mixing of waters of variable qualities between the layers. Improperly completed wells, especially poor casing or cementing, could produce such a result. There are no data suggesting this is currently a problem in the CD-C project area.

3.4.3.6 Springs and Flowing Wells

As described above, water in a confined aquifer is under hydraulic pressure and will rise above the top of the aquifer when the overlying confining bed is broken (spring) or pierced (well). When the hydraulic pressure is great enough, the water from a well completed in a confined aquifer can reach the surface, resulting in a flowing well. Springs and flowing wells are important local water sources for livestock, wildlife, and wild horses. It is unclear how many springs and flowing wells are located within the project area. The SEO records identify two named springs among the 1,081 groundwater rights within 1 mile of the project area (SEO 2011). The SEO records indicate that 118 of the 1,081 groundwater rights are flowing wells (SEO 2011). Of the 1,081 groundwater rights, 325 lack the information to determine if the groundwater permit is for a spring or flowing well.

According to previous studies, springs in the area intercept the ground surface in three geologic units. South of Interstate 80 (I-80), springs occur in the Green River Formation. North of I-80, springs occur in the Wasatch and Battle Springs formations (Mason and Miller 2005; Bartos *et al.* 2006).

Historic water-quality data were located for 16 water samples collected from springs or flowing wells (WRDS 2007, USGS 2007). Water quality for these samples is variable. Conductance levels range from 769 to 16,215 µmhos/cm. TDS levels ranged from 479 to 12,755 mg/L. Detailed information related to springs and flowing wells can be found in **Appendix F**. Based on a February 2011 search of SEO water rights information, none of the 16 springs evaluated for water quality are covered by valid water rights.

3.4.3.7 The Safe Drinking Water Act as it Relates to Groundwater

The Safe Drinking Water Act (SDWA) is the main federal law that regulates drinking water quality, including drinking water from groundwater sources. Under the SDWA, the EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. Two aspects of the SDWA that are relevant to an assessment of the groundwater quality related to the CD-C project are the underground injection control (UIC) program and the sole source aquifer (SSA) protection program. The UIC program ensures that injection wells meet appropriate performance criteria for protecting underground sources of drinking water (USDW). As defined in 40 CFR 144.3, an USDW aquifer supplies any public water system or contains a sufficient quantity of groundwater to supply a public water system; currently supplies drinking water for human consumption or contains fewer than 10,000 mg/l total dissolved solids and is not an exempted aquifer (i.e. exempt from SDWA regulation). The EPA defines an SSA as an aquifer that supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer. While there are no EPA designated SSAs associated with the CD-C project area, there are aquifers in the area that qualify as an USDW.

Quaternary age aquifers within the CD-C project area likely do not qualify as USDWs since there are no wells designated for domestic or municipal use and supply a public water system. Further, the yields from these aquifers are not likely sufficient to sustain a public water system. Tertiary age aquifers within the CD-C project area qualify as USDWs based on the presence of Wamsutter municipal wells and on the suitability of the groundwater quality. Wyoming State Engineer records indicate that one domestic well is completed in the Upper Cretaceous Lance Formation aquifer within the project area.

There are no wells that are designated for municipal use or supply a public water system completed in Upper Cretaceous aquifers within the project area. Upper Cretaceous age aquifers within the CD-C project area qualify as USDWs based on suitability of water quality, on the presence of a sufficient quantity of groundwater to supply a public water system, and the one domestic well completed in the Lance Formation aquifer. Due to the depth of the Upper Cretaceous aquifers in the CD-C area (2,000 to 12,000 feet depending on location [Mason and Miller 2005]) and the low population density of the area, these aquifers are not likely to be the target for large numbers of domestic or public water system wells.

Lower Cretaceous and Jurassic age aquifers within the CD-C project area could qualify as USDW based on suitability of water quality and based on the presence of a sufficient quantity of groundwater to supply a public water system but, due to the depths of the aquifers in the CD-C area (2,000 to 12,000 feet depending on location [Mason and Miller 2005]), Lower Cretaceous and Jurassic age aquifers are not likely to be the target for domestic or public water system wells. Pennsylvanian age and older aquifers within the CD-C project area could qualify as USDW based on the presence of a sufficient quantity of groundwater to supply a public water system but, due to the depths of these aquifers in the CD-C area (4,800 to 18,000 feet depending on location [Mason and Miller 2005]) and the low population density of the area, they are not likely to be the target for domestic or public water system wells.

3.4.4 Injection Wells

As discussed above, subsurface water-disposal methods are administered by the EPA under the UIC program (40 CFR 144). The UIC program ensures that injection wells meet appropriate performance criteria for protecting USDWs. There are five classes of injection wells permitted under the UIC program based on similarity in the fluids injected, activities, construction, injection depth, design, and operating techniques. Class II and Class V injection wells would likely be used to dispose of produced water resulting from the CD-C project. Class II injection well permits are issued by the WOGCC for injection of fluids associated with oil and natural gas production (EPA 2011b),and are issued by the WOGCC under a 1989 Memorandum of Agreement (MOA) between the EPA and the WOGCC. Class V injection wells are permitted through WDEQ-WQD and cover wells not included in Classes I-IV. Most Class V wells (facilities) inject non-hazardous fluids into or above USDWs and are typically shallow, onsite disposal systems (stormwater drainage wells, cesspools, and septic tanks) but also include more complex wells that are deeper and often used for commercial or industrial facilities (EPA 2011b).

According to WOGCC information there are 18 permitted Class II injection wells within the CD-C project area that are capable of operation (WOGCC 2011a). The target injection formations for these wells are Big Red (1), Ericson (1), Fort Union (1), Fort Union/Lance (1), Fox Hills (1), Lewis (1), Mesaverde/Lance (1), Almond (2), Mesaverde (2), and Lance (7). According to WOGCC information there are no permitted Class V injection wells within the project area but there are seven Class V wells adjacent to the project area (WOGCC 2011a). All seven wells are the deeper injection type and target the Haystack Mountain (1), Deep Creek (3), and Mesaverde Coal (3) formations.

3.5 AIR QUALITY

Regional air quality is influenced by a combination of factors including climate, meteorology, the magnitude and spatial distribution of local and regional air pollution sources, and the chemical properties of emitted pollutants. Within the lower atmosphere, regional and local scale air masses interact with regional topography to influence atmospheric dispersion and transport of pollutants. The following sections summarize the climatic conditions and existing air quality within the project area and surrounding region.

3.5.1 Regional Climate

The CD-C project area is located in a semiarid (dry and cold), mid-continental climate regime. The area is typified by dry, windy conditions with limited rainfall and long, cold winters. The nearest meteorological measurements were collected at Wamsutter, Wyoming (1897-2011), located near the center of the project area at an elevation of 6,800 feet above mean sea level; (WRCC 2012).

The annual average total precipitation at Wamsutter is 7.1 inches, with annual totals for the period of record ranging from 3.8 inches (1979) to 13.6 inches (1983). Precipitation is greatest from spring to summer, tapering off during the fall and winter months. An average of 27.4 inches of snow falls during the year (annual high 78.0 inches in 2010), with the majority of the snow distributed evenly between November and April.

The region has cool temperatures, with an average range (in degrees Fahrenheit [˚F]) between 7.1˚F and 28.6˚F in January to between 48.9˚F and 84.5˚F in July. Extreme temperatures have ranged from -40˚F (2011) to 105˚F (1897). The frost-free period generally occurs from May to September. **Table 3.5-1** shows the mean monthly temperature ranges and total precipitation amounts.

Table 3.5-1. Mean Monthly Temperature Ranges and Total Precipitation Amounts

Month	Average Temperature Range (˚F)	Total Precipitation (inches)
January	7.1 – 28.6	0.27
February	10.6 – 33.1	0.29
March	18.4 – 41.8	0.40
April	26.5 – 54.1	0.75
May	34.5 – 65.0	1.07
June	42.4 – 76.5	0.81
July	48.9 – 84.5	0.75
August	46.8 – 82.1	0.81
September	38.5 – 72.5	0.73
October	28.5 – 59.0	0.58
November	17.2 – 41.9	0.36
December	8.5 – 29.9	0.28
ANNUAL	41.5 (mean)	7.11 (mean)

Source: WRCC 2012

The CD-C project area is subject to strong and gusty winds, often accompanied by snow during the winter months, producing blizzard conditions and drifting snow. The closest comprehensive wind measurements were collected in the project area at the WDEQ meteorological monitoring station located approximately 2 miles northwest of Wamsutter. To describe the wind flow pattern for the region a wind rose for the Wamsutter site, for years 2008 through 2010, is presented in **Figure 3.5-1**. **Tables 3.5-2 and 3.5-3** provide the wind speed and wind direction distributions in tabular format. From this information, it is evident that the winds originate from the west to southwest nearly 36 percent of the time and from the south to southeast over 37 percent of the time.

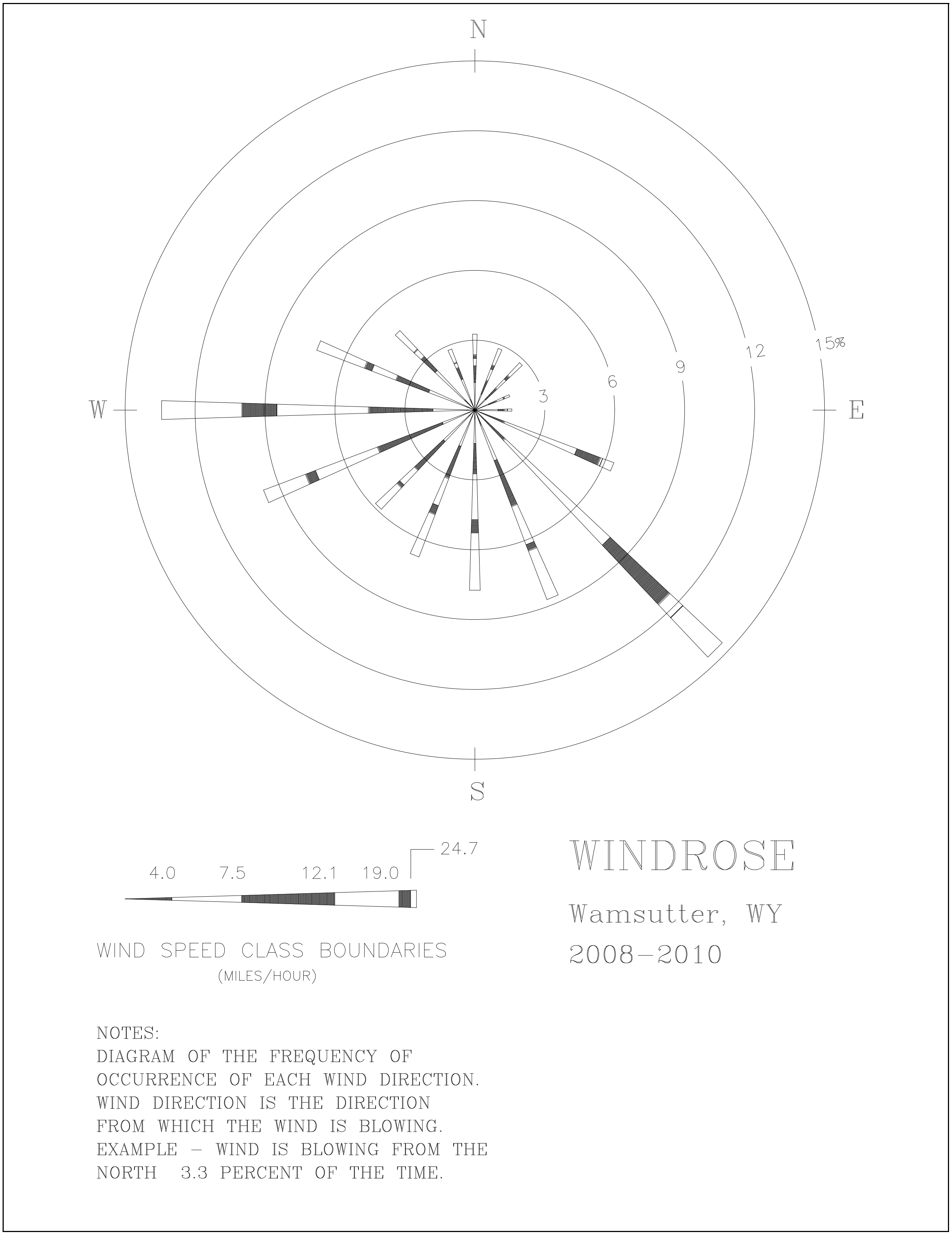


Figure 3.5-1. Wamsutter, WY meteorological data wind rose

The frequency and strength of winds greatly affect the transport and dispersion of air pollutants. The annual mean wind speed is 11.4 miles per hour (mph), and the relatively high average wind speed indicates good dispersion and mixing of any potential pollutant emissions.

Table 3.5-2. Wind Speed Distribution, Wamsutter, Wyoming, 2008–2010[1]

Wind Speed (mph)	Frequency (%)
0 – 4.0	8.3
4.0 – 7.5	25.0
7.5 – 12.1	22.6
12.1 – 19.0	16.9
19.0 – 24.7	4.5
Greater than 24.7	2.3

[1]*Source: WDEQ-AQD 2012.*

Table 3.5-3. Wind Direction Frequency Distribution, Wamsutter, Wyoming, 2008–2010

Wind Direction	Frequency (%)
N	3.3
NNE	2.8
NE	2.8
ENE	1.6
E	1.6
ESE	6.4
SE	14.6
SSE	8.7
S	7.7

Wind Direction	Frequency (%)
SSW	6.8
SW	5.9
WSW	9.7
W	13.4
WNW	7.3
NW	4.7
NNW	2.8

Source: WDEQ-AQD 2012.

3.5.2 Overview of Regulatory Environment

The WDEQ-AQD is the primary air quality regulatory agency responsible for estimating impacts once detailed industrial development plans have been made, and those development plans are subject to applicable air quality laws, regulations, standards, control measures, and management practices. Unlike the conceptual ‘reasonable, but conservative’ engineering designs used in NEPA analyses, any WDEQ-AQD air quality preconstruction permitting demonstrations required would be based on very site-specific, detailed engineering values, which would be assessed in the permit application review. Any proposed facility which meets the requirements set forth under Wyoming Air Quality Standards and Regulations (WAQSR) Chapter 6 is subject to the WDEQ-AQD permitting and compliance processes.

Federal air quality regulations adopted and enforced by WDEQ-AQD limit incremental emission increases to specific levels defined by the classification of air quality in an area. The Prevention of Significant Deterioration (PSD) Program is designed to limit the incremental increase of specific air pollutant concentrations above a legally defined baseline level. Incremental increases in PSD Class I areas are strictly limited, while increases allowed in Class II areas are less strict. Under the PSD program, Class I areas are protected by Federal Land Managers (FLMs) through management of air quality related values ((AQRVs) such as visibility, aquatic ecosystems, flora, fauna, and others.

The 1977 Clean Air Act amendments established visibility as an AQRV for FLMs to consider. The 1990 Clean Air Act amendments contain a goal of improving visibility within PSD Class I areas. The Regional Haze Rule finalized in 1999 requires states, in coordination with federal agencies and other interested parties, to develop and implement air quality protection plans to reduce the pollution that causes visibility impairment.

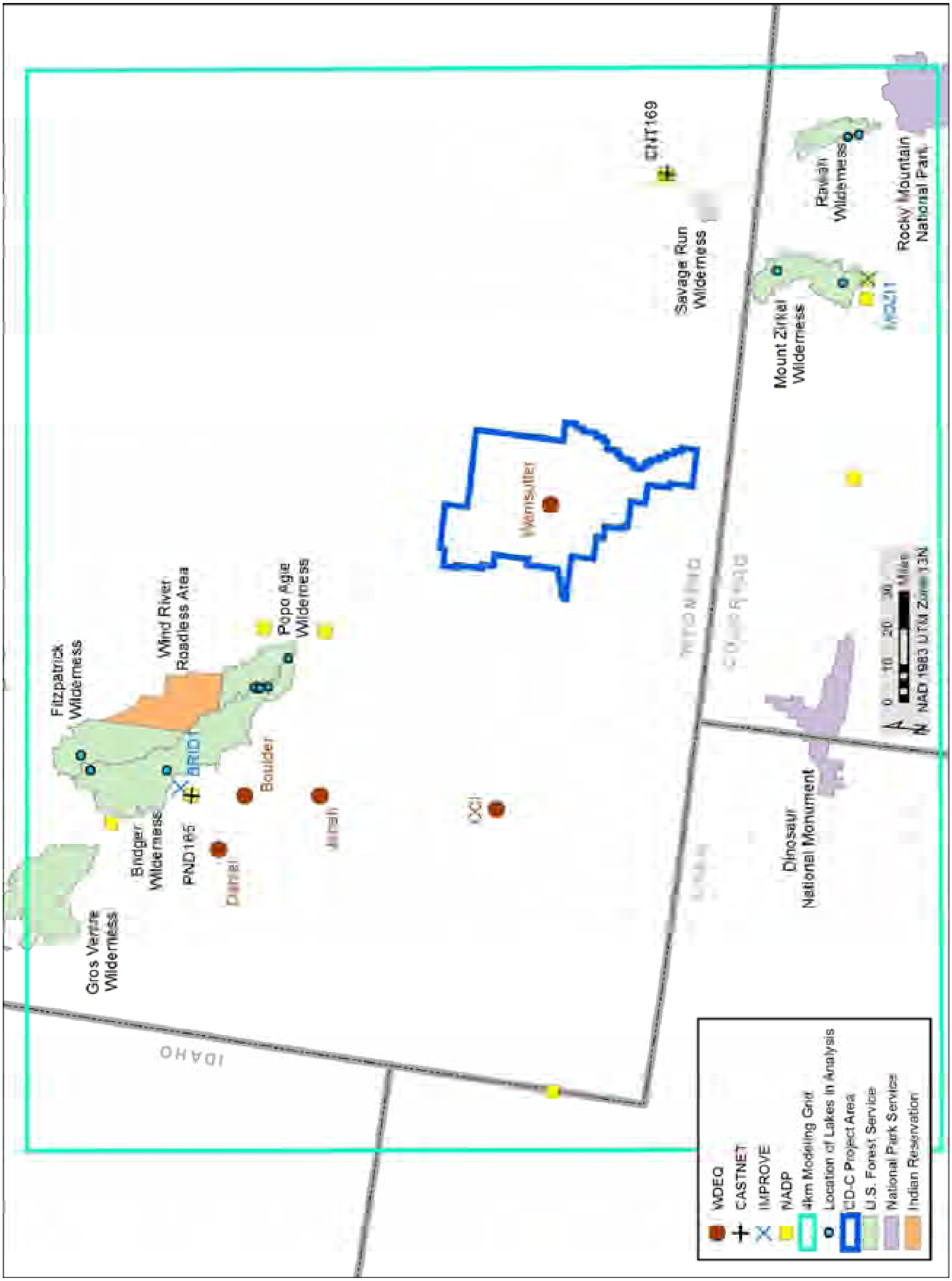
Regulations and standards which limit permissible levels of air pollutant concentrations and air emissions and are relevant to the CD-C project air impact analysis include:

- NAAQS (40 CFR Part 50) , WAAQS (WAQSR Chapter 2), CAAQS (5 CCR 1001-14);
- Prevention of Significant Deterioration (40 CFR Part 51.166);
- New Source Performance Standards (NSPS) (40 CFR Part 60);
- Non-Road Engine Tier Standards (40 CFR Part 89); and
- Wyoming 2010 Oil and Gas Permitting Guidance (supplement to WAQSR Chapter 6, Section 2)

Each of these regulations is further described in the following sections.

3.5.2.1 Ambient Air Quality Standards

The Clean Air Act requires the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered to endanger public health and the environment. The NAAQS prescribe limits on ambient levels of these pollutants in order to protect public health, including the health of sensitive groups. The EPA has developed NAAQS for six criteria pollutants: NO_2, CO, SO_2, PM_{10}, $PM_{2.5,}$ ozone, and lead. Lead emissions from CD-C project sources are negligible and therefore the lead NAAQS is not addressed in this analysis. States typically adopt the NAAQS but may also develop state-specific ambient air quality standards for certain pollutants. The NAAQS and the state ambient air quality standards for Wyoming (WAAQS) and Colorado (CAAQS) are summarized in **Table 3.5-4.** The CAAQS are included in this table due to the proximity of the CD-C project area to Colorado (See **Map 3.5-1**). PSD Class I and Class II increments are also included in Table 3.5-7 and a discussion of PSD increments is provided in **Section 3.5.2.3**. The ambient air quality standards are shown in units of parts per million (ppm), parts per billion (ppb), and micrograms per cubic meter ($\mu g/m^3$) for purposes of providing the standards as written in the corresponding regulation, and for comparison with the pollutant concentration units as provided by the air quality models used for impact analysis (**Section 4.5**).



Map 3.5-1. Air quality monitoring stations within the CD-C study area

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

Table 3.5-4. Ambient air quality standards and PSD increments (μg m^3)

Pollutant	Averaging Time	NAAQS			CAAQS			WAAQS		
		(ppm)	(ppb)	($\mu g/m^3$)	(ppm)	(ppb)	($\mu g/m^3$)	(ppm)	(ppb)	($\mu g/m^3$)
CO	1-hour[1]	35	35,000	40,000	35	35,000	40,000	35	35,000	40 (mg/m^3)
	8-hour[1]	9	9,000	10,000	9	9,000	10,000	9	9,000	10 (mg/m^3)
NO_2	1-hour[2]	0.1	100	188	0.1	100	188	--	--	--
	Annual[3]	0.053	53	100	0.053	53	100	0.053	53	100
Ozone	8-hour[4]	0.075	75	147	0.075	75	147	0.08	80	157
PM_{10}	24-hour[1]	NA	NA	150	NA	NA	150	NA	NA	150
	Annual[3]	NA	NA	--[5]	NA	NA	--	NA	NA	50
$PM_{2.5}$	24-hour[6]	NA	NA	35	NA	NA	35	NA	NA	35
	Annual[3]	NA	NA	15	NA	NA	15	NA	NA	15
SO_2	1-hour[7]	0.075	75	196	0.075	75	196	--	--	--
	3-hour[1]	0.5	500	1,300	0.267	267	700	0.5	500	1,300
	24-hour[1]	--[5]	--	--	--	--	--	0.10	100	260
	Annual[3]	--[5]	--	--	--	--	--	0.02	23	60

*Note: **Bold** indicates the standard as written the corresponding regulation. Other values are conversions.*

[1] *Not to be exceeded more than once per year.*

[2] *An area is in compliance with the standard if the 98th percentile of daily maximum 1-hour NO_2 concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.*

[3] *Annual arithmetic mean.*

[4] *An area is in compliance with the standard if the fourth-highest daily maximum 8-hour ozone concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.*

[5] *The NAAQS for this averaging time for this pollutant has been revoked by EPA.*

[6] *An area is in compliance with the standard if the highest 24-hour $PM_{2.5}$ concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.*

[7] *An area is in compliance with the standard if the 99th percentile of daily maximum 1-hour SO_2 concentrations in a year, averaged over 3 years, is less than or equal to the level of the standard.*

An area that is shown to exceed the NAAQS for a given pollutant may be designated as a non-attainment area for that pollutant. In March 2009, the Governor of Wyoming recommended to the EPA that Sublette County and parts of northeastern Lincoln and northwestern Sweetwater Counties be designated non-attainment for ozone due to exceedances of the 2008 75 parts per billion ozone NAAQS. The CD-C project area is located in eastern Sweetwater and western Carbon counties, outside of the proposed non-attainment area. In April 2012, Sublette County and parts of Lincoln and Sweetwater were designated by the EPA as nonattainment areas under the 2008 ozone standard <http://www.epa.gov/groundlevelozone/-designations/2008standards/final/region8f.htm>.

3.5.2.2 Hazardous Air Pollutants

Toxic air pollutants, also known as hazardous air pollutants (HAPs), are those pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. No ambient air quality standards exist for HAPs; instead, emissions of these pollutants are controlled by a variety of regulations that target the specific source class and industrial sectors for stationary, mobile, and product use/formulations. Sources of HAPs from CD-C operations include well-site production emissions (benzene, toluene, ethyl benzene, xylene, n-hexane, and formaldehyde), and compressor station and gas plant combustion emissions (formaldehyde).

For the CD-C analysis, short-term (1-hour) HAP concentrations are compared to acute Reference Exposure Levels (RELs) (EPA, 2011) shown in **Table 3.5-5**. RELs are defined as concentrations at or below which no adverse health effects are expected. No RELs are available for ethyl benzene and n-hexane; instead, the available “Immediately Dangerous to Life or Health” values divided by 10 (IDLH/10) are used. These IDLH values were determined by the National Institute for Occupational

Safety and Health and were obtained from EPA's Air Toxics Database (EPA, 2011). These values are approximately comparable to mild effects levels for 1-hour exposures.

Long-term exposure to HAPs are compared to Reference Concentrations for Chronic Inhalation (RfCs). An RfC is defined by the EPA as the daily inhalation concentration at which no long-term adverse health effects are expected. RfCs exist for both non-carcinogenic and carcinogenic effects on human health (EPA, 2010). Annual modeled HAP concentrations for all HAPs emitted were compared directly to the non-carcinogenic RfCs shown in **Table 3.5-6**..

Long-term exposures to emissions of suspected carcinogens (benzene, ethyl benzene and formaldehyde) are also evaluated based on estimates of the increased latent cancer risk over a 70-year lifetime.

Table 3.5-5. Acute RELs (1-hour exposure)

HAP	REL ($\mu g/m^3$)
Benzene	1,300[1]
Toluene	37,000[1]
Ethyl Benzene	350,000[2]
Xylene	22,000[1]
n-Hexane	390,000[2]
Formaldehyde	55[1]

[1] EPA Air Toxics Database, Table 2 (EPA, 2011).

[2] No REL available for these HAPs. Values shown are from Immediately Dangerous to Life or Health (IDLH/10), EPA Air Toxics Database, Table 2 (EPA, 2011).

Table 3.5-6. Non-Carcinogenic HAP RfCs (annual average)[1]

HAP	Non-CarcinogenicRfC[1] ($\mu g/m^3$)
Benzene	30
Toluene	5000
Ethyl Benzene	1,000
Xylenes	100
n-Hexane	700
Formaldehyde	9.8

[1] EPA Air Toxics Database, Table 1 (EPA, 2010).

3.5.2.3 Prevention of Significant Deterioration

The PSD Program is designed to limit the incremental increase of specific air pollutant concentrations above a legally defined baseline level. All areas of the country are assigned a classification which describes the degree of degradation to the existing air quality that is allowed to occur within the area under the PSD permitting rules. PSD Class I areas are areas of special national or regional natural, scenic, recreational, or historic value, and very little degradation in air quality is allowed by strictly limiting industrial growth. PSD Class II areas allow for reasonable industrial/economic expansion. Certain national parks and wilderness areas are designated as PSD Class I, and air quality in these areas is protected by allowing only slight incremental increases in pollutant concentrations. Five PSD Class I areas are located within the CD-C study area as shown on **Map 3.5-1**: the Bridger, Fitzpatrick, Mount Zirkel, Savage Run, and Rawah Wilderness Areas. In a PSD increment analysis, impacts from proposed emissions sources are compared with the allowable limits on increases in pollutant concentrations, which are called Class I PSD increments; these increments are shown in **Table 3.5-7**. Dinosaur National Monument is a federal PSD Class II area given Class I protection for SO_2 by the Colorado Department of Public Health and Environment (CDPHE). The remainder of the impact study area is classified as PSD Class II, where less stringent limits on increases in pollutant concentrations apply. The Popo Agie

Wilderness Area and the Wind River Roadless Area are considered sensitive areas and are subject to the PSD Class II Increments shown in Table 3.5-7.

Table 3.5-7. PSD increments (μg/m^3)

Pollutant	Averaging Time	PSD Class I Increment	PSD Class II Increment
NO_2	1-hour	None	None
	Annual	2.5	25
PM_{10}	24-hour	8	30
	Annual	4	17
$PM_{2.5}$	24-hour	2	9
	Annual	1	4
SO_2	1-hour	None	None
	3-hour	25	512
	24-hour	5	91
	Annual	2	20

Note: The PSD demonstrations serve information purposes only and do not constitute a regulatory PSD increment consumption analysis.

Comparisons of CD-C project impacts to the PSD Class I and II increments are for informational purposes only and are intended to evaluate a threshold of concern. They do not represent a regulatory PSD Increment Consumption Analysis, which would be completed as necessary during the New Source Review permitting process by the State of Wyoming.

In addition to the PSD increments, Class I areas are protected by FLMs through management of AQRVs such as visibility, aquatic ecosystems, flora, and fauna. Evaluations of impacts to AQRVs would also be performed during the New Source Review permitting process under the direction of the WDEQ-AQD in consultation with the FLMs.

AQRVs that were identified as a concern for the CD-C project included visibility, atmospheric deposition, and potential sensitive lake acidification. A discussion of the applicable background data and analysis thresholds is provided below.

Visibility

Change in atmospheric light extinction relative to background conditions is used to measure regional haze. Analysis thresholds for atmospheric light extinction are set forth in The Federal Land Managers' Air Quality Related Values Work Group (FLAG) Report (FLAG 2010), with the results reported in percent change in light extinction and change in deciviews (dv). A 5-percent change in light extinction (approximately equal to 0.5 dv) is the threshold recommended in FLAG (2010) and is considered to contribute to regional haze visibility impairment. A 10-percent change in light extinction (approximately equal to 1.0 dv) is considered to represent a noticeable change in visibility when compared to background conditions.

Estimated visibility degradation at the Class I areas and sensitive Class II areas of concern are presented in terms of the number of days that exceed a threshold percent change in extinction, or dv relative to background conditions. Although procedures and thresholds have not been established for sensitive Class II areas, BLM is including these areas in its visibility analysis.

Atmospheric Deposition and Lake Chemistry

The effects of atmospheric deposition of nitrogen and sulfur compounds on terrestrial and aquatic ecosystems are well documented and have shown to cause leaching of nutrients from soils, acidification of surface waters, injury to high-elevation vegetation, and changes in nutrient cycling and species composition. FLAG (2010) recommends that applicable sources assess impacts of nitrogen and sulfur deposition in Class I areas.

This guidance recognizes the importance of establishing critical deposition loading values ("critical loads") for each specific Class I area as these critical loads are completely dependent on local atmospheric, aquatic, and terrestrial conditions and chemistry. Critical load thresholds are essentially a level of atmospheric pollutant deposition below which negative ecosystem effects are not likely to occur. FLAG 2010 does not include any critical load levels for specific Class I areas and refers to site-specific critical load information on FLM websites for each area of concern. This guidance does, however, recommend the use of deposition analysis thresholds (DATs) developed by the National Park Service (NPS) and the Fish and Wildlife Service (USFWS). The DATs represent screening level values for nitrogen and sulfur deposition from project alone emission sources below which estimated impacts are considered negligible. The DAT established for both nitrogen and sulfur in western Class I areas is 0.005 kilograms per hectare per year (kg/ha/yr).

In addition to the screening level analysis, project-specific and cumulative modeled results are compared to critical load thresholds established for the Rocky Mountain region to assess total deposition impacts. The BLM has compiled currently available research data on critical load values for Class I areas in the vicinity of the CD-C project area. Critical load thresholds published by Fox et al. (Fox 1989) established pollutant loadings for total nitrogen of 3–5 kg/ha/yr) and for total sulfur of 5 kg/ha/yr for Bob Marshall Wilderness Area in Montana and Bridger Wilderness Area in Wyoming. However, the NPS has recently stated that these pollutant loadings are not protective of sensitive resources and in its *"Technical Guidance on Assessing Impacts to Air Quality in NEPA and Planning Documents"* (January 2011) suggested that critical load values above 3 kg/ha/yr may result in moderate impacts. Research conducted by Jill Baron (Baron 2006) using hindcasting of diatom communities suggests 1.5 kg/ha/yr as a critical loading value for wet nitrogen deposition for high-elevation lakes in Rocky Mountain National Park, Colorado. Recent research conducted by Saros et. al. (2010) using fossil diatom assemblages suggest that a critical load value of 1.4 kg/ha/yr for wet nitrogen is applicable to the eastern Sierra Nevada and Greater Yellowstone ecosystems. For the CD-C project, both project-specific and cumulative nitrogen and sulfur deposition impacts are compared to the following critical load values: 1.5 kg/ha/yr as a surrogate for total nitrogen deposition and 3 kg/ha/yr for total sulfur deposition for the Class I and sensitive Class II areas evaluated.

Analyses to assess the change in water chemistry associated with atmospheric deposition are performed following the procedures developed by the USFS Rocky Mountain Region (USFS 2000). The analysis assesses the change in the acid neutralizing capacity (ANC) of the 12 sensitive lakes (**Table 3.5-6**) within the CD-C study area (**Map 3.5-1**). Predicted changes in ANC are compared with the applicable threshold for each identified lake: 10-percent change in ANC for lakes with background ANC values greater than 25 microequivalents per liter [μeq/L], and less than a 1-μeq/L change in ANC for lakes with background ANC values equal to or less than 25 μeq/L.

3.5.2.4 New Source Performance Standards

Under Section 111 of the Clean Air Act, the EPA has promulgated technology-based emissions standards which apply to specific categories of stationary sources. These standards are referred to as New Source Performance Standards (NSPS; 40 CFR Part 60). The NSPS potentially applicable to the CD-C project include the following subparts of 40 CFR Part 60:

- Subpart A – General Provisions;
- Subpart Kb – Standards of Performance for Volatile Organic Storage Vessels;
- Subpart JJJJ – Standards of Performance for Stationary Spark-Ignition Internal Combustion Engines; and
- Subpart KKKK – Standards of Performance for Stationary Combustion Turbines.

Subpart A – General Provisions

Provisions of Subpart A apply to the owner or operator of any stationary source which contains an affected facility, the construction or modification of which is commenced after the date of publication in this part of any standard (or, if earlier, the date of publication of any proposed standard) applicable to that facility. Provisions of Subpart A could apply to proposed CD-C sources that are affected by NSPS.

Subpart Kb – Volatile Organic Liquid Storage Vessels

Subpart Kb applies to storage vessels with a capacity greater than or equal to 75 cubic meters (m^3) that are used to store volatile organic liquids for which construction, reconstruction, or modification is commenced after July 23, 1984. This subpart potentially would be applicable to storage tanks for natural gas liquids.

Subpart JJJJ – Spark Ignition Internal Combustion Engines

Subpart KKKK establishes emission standards and compliance schedules for the control of emissions from stationary combustion turbines that commenced construction, modification or reconstruction after February 18, 2005. Stationary combustion turbines with a heat input at peak load equal to or greater than 10.7 gigajoules (10 MMBtu) per hour, based on the higher heating value of the fuel proposed as part of the CD-C project, would be subject to this NSPS.

Subpart KKKK – Stationary Combustion Turbines

Subpart KKKK establishes emission standards and compliance schedules for the control of emissions from stationary combustion turbines that commenced construction, modification or reconstruction after February 18, 2005. Stationary combustion turbines with a heat input at peak load equal to or greater than 10.7 gigajoules (10 MMBtu) per hour, based on the higher heating value of the fuel proposed as part of the CD-C project would be subject to this NSPS.

3.5.2.5 Non-Road Engine Tier Standards

The EPA sets emissions standards for non-road diesel engines for hydrocarbons, NO_X, CO, and PM. The emissions standards are implemented in tiers by year, with different standards and start years for various engine power ratings. The new standards do not apply to existing non-road equipment. Only equipment built after the start date for an engine category (1999-2006, depending on the category) is affected by the rule. Over the life of the CD-C project, the fleet of non-road equipment will turn over and higher-emitting engines will be replaced with lower-emitting engines. This fleet turnover is accounted for in the CD-C project emissions inventory.

3.5.2.6 Wyoming 2010 Oil and Gas Permitting Guidance (Wyoming BACT)

The CD-C project area lies entirely within eastern Sweetwater County and western Carbon County in Wyoming; this area is part of the State of Wyoming's Concentrated Development Area (CDA; **Map 3.5-3**), and is therefore subject to CDA restrictions on emissions set forth in the WDEQ-AQD's March 2010 "Oil and Gas Production Facilities Chapter 6, Section 2 Permitting Guidance" (WDEQ-AQD, 2010). The Guidance states, "….all new or modified sources or facilities which may generate regulated air emissions shall be permitted prior to start-up or modification and Best Available Control Technology (BACT) shall be applied to reduce or eliminate emissions". The Guidance establishes presumptive BACT requirements for emissions from the following source categories for new facilities:

- Tank Flashing[8] (see Glossary). Pad facilities: 98-percent control upon startup; single-well facilities: 98-percent control of all new/modified tank emissions ≥ 8 tpy (tons per year) VOC within 60 days of startup/modification.
- Dehydration Units. Upon first date of production (FDOP), glycol flash separators and still vent condensers must be installed/operating on all dehydrators; 98-percent control must be installed/operational on dehydrators within 30 days of FDOP if total potential uncontrolled dehydrator VOC emissions are ≥8 tpy; combustion units used to achieve 98-percent control may be removed upon approval after 1 year if total potential VOC emissions from dehydrators are <8 tpy.
- Pneumatic Pumps. Pad facilities: VOC and HAP emissions associated with the discharge streams of all natural gas-operated pneumatic pumps controlled by at least 98 percent or the pump discharge streams routed into a closed-loop system such as sales line, collection line, fuel supply; single-well facilities with combustion units installed for the control of flash or dehydration unit emissions: VOC and HAP emissions associated with the discharge streams from natural gas-operated pneumatic pumps controlled by at least 98 percent by routing the pump discharge streams into the combustion unit or the discharge streams routed into a closed loop system.
- Pneumatic Controllers. Install low- or no-bleed controllers at all new facilities.
- Well Completions. Green completions are required in the Jonah, Pinedale and Anticline development fields (JPAD) area and concentrated development areas (**Map 3.5-2**).
- Produced Water Tanks. Pad facilities-upon FDOP, 98-percent control of all produced water tank emissions. No water produced into open-top tanks; single-well facilities within 60 days of FDOP, 98-percent control of all produced water tank emissions at sites where flashing emissions must be controlled. No water produced into open-top tanks.
- Blow-down/Venting. Best Management Practices and information-gathering requirements incorporated into permits for new and modified facilities.
- Other sources. For uncontrolled sources emitting ≥8 tpy VOC or ≥5 tpy total HAPs that do not have presumptive BACT requirements, a BACT analysis must be filed with the permit application for the associated facility.

[8] Flashing losses occur when a liquid with entrained gases goes from a higher pressure to a lower pressure. As the pressure on the liquid drops, some of the compounds dissolved in the liquid are released, or “flashed” as gas.

Map 3.5-2. The concentrated development area (from WDEQ-AQD, 2010)

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

3.5.2.7 Greenhouse Gases (GHGs)

Greenhouse gases (GHGs) present in the earth's atmosphere trap outgoing longwave radiation and warm the earth's atmosphere. Higher concentrations of GHGs in the atmosphere result in more heat being absorbed and cause higher global temperatures. Some GHGs, such as water vapor, occur naturally in the atmosphere, and some such as carbon dioxide (CO_2) and methane (CH_4) occur naturally and are also emitted by human activities. The global atmospheric concentration of CO_2 has increased by about 36 percent over the last 250 years, and far exceeds pre-industrial values determined from ice cores spanning many thousands of years (IPCC, 2007). The anthropogenic GHGs of primary concern are: CO_2, CH_4, NO_2 and fluorinated gases. Ice core records extending back over thousands of years indicate that worldwide emissions of these anthropogenic GHGs have increased dramatically during the industrial era with an increase of 70 percent between 1970 and 2004 alone (IPCC, 2007).

The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme and the World Meteorological Organization in 1988 to provide a clear scientific view on the current state of knowledge about climate change and its potential environmental and socioeconomic impacts. The main activity of the IPCC is to provide at regular intervals Assessment Reports of the state of knowledge on climate change. The latest report is "Climate Change 2007," the IPCC Fourth Assessment Report (AR4). (IPCC 2007). In AR4, the IPCC concluded that warming of the climate system is unequivocal and most of the observed increase in global average temperatures since the mid 20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations. The IPCC further concluded that, "continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century."

The impacts of climate change are expected to vary by region, and there is significant uncertainty regarding the effects of climate change on any particular region. In particular, it is unknown how climate change will affect the CD-C project area or its surrounding environment. However, AR4 identified specific risks for North America as a whole, and these are shown below:

- Warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources.
- In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20 percent, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilized water resources.
- Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity, and duration of heat waves during the course of the century, with potential for adverse health impacts.
- Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.

The GHGs projected to be emitted by the CD-C Project Alternatives are CO_2, CH_4 and $NO_{2.}$ The atmospheric lifetimes for CO_2, CH_4 and NO_2 are on the order of years (IPCC, 2007). Emissions of GHGs from any particular source become well-mixed throughout the global atmosphere. GHG emissions from all sources contribute to the global atmospheric burden of GHGs, and it is not possible to attribute a particular climate impact in any given region to GHG emissions from a particular source. It is possible to state only that GHG emissions produced by the Proposed Action and action alternatives would add to the global burden of GHGs and may therefore contribute to climate change impacts to the Affected Environment produced by world-wide emissions; these impacts may include those shown above.

In 2007, the U.S. Supreme Court ruled in *Massachusetts v. EPA* that EPA has the authority to regulate greenhouse gases such as CH_4 and CO_2 as air pollutants under the Clean Air Act. The ruling did not, however, require the EPA to create any emission control standards or ambient air quality standards for GHGs. At present there are no ambient air quality standards for GHGs, and there are no emissions limits on GHGs that would apply to the sources developed under the Proposed Action and the action alternatives. There are, however, applicable reporting requirements under the EPA's Greenhouse Gas Reporting Program. These GHG emission reporting requirements, finalized in 2010 under 40 CFR Part 98, will require the Operators to develop and report annual methane and CO_2 emissions from equipment leaks and venting, and emissions of CO_2, CH_4, and N_2O from flaring, onshore production stationary and portable combustion emissions, and combustion emissions from stationary equipment. At present, there are no rules related to GHG emissions or impacts that would affect development of the Proposed Action or the action alternatives besides these GHG reporting requirements.

3.5.3 Air Pollutant Concentrations

The U.S. EPA and the states set limits on permissible concentrations of air pollutants. The National Ambient Air Quality Standards (NAAQS), Wyoming Ambient Air Quality Standards (WAAQS), and Colorado Ambient Air Quality Standards (CAAQS) are health-based criteria for the maximum acceptable concentrations of air pollutants at all locations to which the public has access.

Monitoring of air pollutant concentrations has been conducted within both the CD-C project area and the study area, shown in **Map 3.5-1**. Map 3.5-1 presents the locations of ambient air monitoring sites within the study area. These monitoring sites are part of several monitoring networks overseen by state and federal agencies, including: WDEQ (State of Wyoming), Clean Air Status and Trends Network (CASTNET), Interagency Monitoring of Protected Visual Environments (IMPROVE), and National Acid Deposition Program (NADP) National Trends Network (NTN).

The study area shown in **Map 3.5-1** encompasses five Prevention of Significant Deterioration (PSD) Class I areas and three sensitive Class II areas. The five Class I areas located within the CD-C study area are the Bridger, Fitzpatrick, Mount Zirkel, Savage Run, and Rawah Wilderness Areas, and the three sensitive Class II areas are the Popo Agie Wilderness Area, Dinosaur National Monument, and Wind River Roadless Area.

Air pollutants monitored at these sites include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone, particulate matter less than 10 microns in effective diameter (PM_{10}), particulate matter less than 2.5 microns in effective diameter ($PM_{2.5}$), and sulfur dioxide (SO_2). Background concentrations of these pollutants define ambient air concentrations in the region and establish existing compliance with ambient air quality standards. The most representative monitored regional background concentrations available for criteria pollutants as identified by WDEQ-AQD (WDEQ-AQD, 2011) are shown in **Table 3.5-8**.

Table 3.5-8. Background ambient air quality concentrations (μg/m^3)

Pollutant	Averaging Period	Measured Background Concentration
CO[1]	1-hour 8-hour	1,026 798
NO_2[2]	1-hour Annual	75 9.1
O_3[3]	8-hour	126.1
PM_{10}[4]	24-hour Annual	56 13.5
$PM_{2.5}$[5]	24-hour Annual	9.2 4.2
SO_2[6]	1-hour 3-hour 24-hour Annual	19.7 11.5 4.2 3.8

[1] Data collected during 2008 at Murphy Ridge, Wyoming; concentrations are maximum values.

[2] Data collected at Wamsutter, Wyoming: 1-hour concentration is the three year average (2008-2010) of daily maximum 98th percentile 1-hour concentrations, annual value is for 2010.

[3] Data collected at Wamsutter, Wyoming: 8-hour concentration is the three year average (2008-2010) of the fourth-highest daily maximum 8-hour concentrations.

[4] Data collected at Wamsutter, Wyoming during 2010, 24-hour value is maximum concentration.

[5] Data collected at Cheyenne, Wyoming: 24-hour value is the three year average (2008-2010) of daily maximum 98th percentile 24-hour concentrations, annual value is three year average of annual means (2008-2010).

[6] Data collected at Wamsutter, Wyoming: 1-hour value is the three year average (2007-2009) of daily maximum 98th percentile 1-hour concentrations, 3-hour, 24-hour and annual concentrations were collected during 2009, 3-hour and 24-hour data are maximum values.

3.5.4 Air Quality Related Values

An AQRV is a resource “that may be adversely affected by a change in air quality. The resource may include visibility or a specific scenic, cultural, physical, biological, ecological, or recreational resource (FLAG 2010). The (AQRVs) visibility, atmospheric deposition, and the change in water chemistry associated with atmospheric deposition at acid-sensitive lakes have been identified as a concern at several Class I and sensitive Class II areas within the study area.

Visibility conditions can be measured as standard visual range (SVR), the farthest distance at which an observer can just see a black object viewed against the horizon sky; the larger the SVR, the cleaner the air. Visibility for the region is considered to be very good. Continuous visibility-related optical background data have been collected in the PSD Class I Mount Zirkel and Bridger Wilderness Areas, as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. The average SVR at the both the Mount Zirkel and Bridger Wilderness Areas is over 200 kilometers (Visibility Information Exchange Web System [VIEWS] 2012).

Atmospheric deposition refers to the processes by which air pollutants are removed from the atmosphere and deposited on terrestrial and aquatic ecosystems, and it is reported as the mass of material deposited on an area per year (kg/ha-yr). Air pollutants are deposited by wet deposition (precipitation) and dry deposition (gravitational settling of pollutants). The chemical components of wet deposition include sulfate (SO_4), nitrate (NO_3), and ammonium (NH_4); the chemical components of dry deposition include SO_4, SO_2, NO_3, NH_4, and nitric acid (HNO_3).

The National Acid Deposition Program (NADP) and the National Trends Network (NTN) station monitors wet atmospheric deposition and the Clean Air Status and Trends Network (CASTNET) station monitors dry atmospheric deposition at sites near Centennial/Brooklyn Lake, and Pinedale which are approximately 65 miles east-southeast, and 95 miles northwest, respectively, of the project area. The total annual deposition (wet and dry) reported as total nitrogen and total sulfur deposition for year 2009 at shown in **Table 3.5-9**.

Table 3.5-9. Background nitrogen and sulfur deposition values (kg/ha-yr)

Site Location	Nitrogen Deposition			Sulfur Deposition			Year of Monitoring
	Wet	Dry	Total	Wet	Dry	Total	
Centennial	2.60	0.53	3.13	1.51	0.17	1.68	2009
Pinedale	1.00	0.34	1.34	0.47	0.14	0.61	2009

EPA (2012b).

Table 3.5-10 presents a list of 12 lakes within the study area that have been identified as acid sensitive. Analyses for potential changes to lake acidity from atmospheric deposition are based on the ANC for the lake. The most recent lake chemistry background ANC data are also shown in **Table 3.5-9**. The ANC values shown are the 10th percentile lowest ANC values which were calculated for each lake following procedures provided from the USFS. The years of monitoring data that were currently available, and the number of samples used in the calculation of the 10^{th} percentile lowest ANC values, are provided.

Of the 12 lakes listed in Table 3.5-10, two lakes (Lazy Boy and Upper Frozen) are considered by the USFS as extremely sensitive to atmospheric deposition since the background ANC values are less than 25 microequivalents per liter (µeq/l).

Table 3.5-10. Background ANC values for acid-sensitive lakes

Wilderness Area	Lake	Latitude (Deg-Min-Sec)	Longitude (Deg-Min-Sec)	10th Percentile Lowest ANC Value (µeq/l)	Number of Samples	Monitoring Period
Bridger	Black Joe	42º44'22"	109º10'16"	69.7	78	1984-2009
Bridger	Deep	42º43'10"	109º10'15"	60.4	75	1984-2009
Bridger	Hobbs	43º02'08"	109º40'20"	70.1	85	1984-2009
Bridger	Lazy Boy	43º19'57"	109º43'47"	12.4	5	1997-2009
Bridger	Upper Frozen	42º41'13"	109º09'39"	7.4	12	1997-2009
Fitzpatrick	Ross	43º22'41"	109º39'30"	54.1	60	1988-2009
Mount Zirkel	Lake Elbert	40º38'3"	106º42'25"	53.6	67	1985-2007
Mount Zirkel	Seven Lakes	40º53'45"	106º40'55"	40.5	24	1985-2007
Mount Zirkel	Summit Lake	40º32'43"	106º40'55"	48.0	108	1985-2007
Popo Agie	Lower Saddlebag	42º37'24"	108º59'38"	55.6	59	1989-2009
Rawah	Island	40º37'38"	105º56'28"	71.4	21	1996-2009
Rawah	Rawah Lake #4	40º40'16"	105º57'28"	41.6	26	1996-2009

Source: USFS (2010).

■ BIOLOGICAL ENVIRONMENT

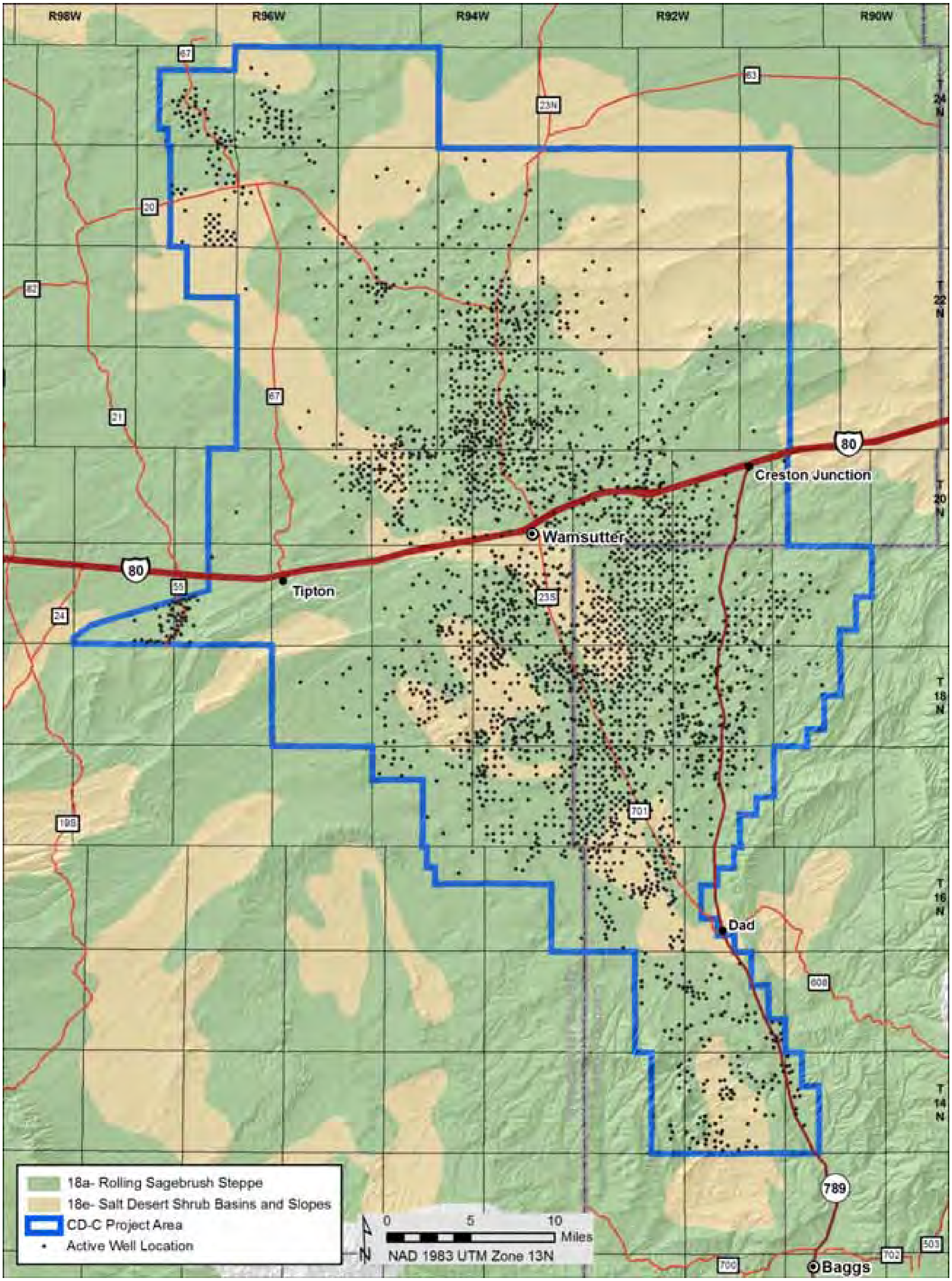
3.6 VEGETATION AND BIOLOGICAL SOIL CRUSTS

3.6.1 Introduction

The CD-C project area is located within the Omernik Level III "Wyoming Basin" Ecoregion 18 (Omernik 1987). This ecoregion is described as a broad intermontane basin dominated by arid grasslands and shrublands and interrupted by high hills and low mountains. Ecoregion 18 is further divided into seven smaller Level IV Ecoregions (18a through 18g) to provide a better description of local diversity within the Wyoming Basin (Chapman *et al.* 2004). Two of these Level IV Ecoregions are present within the project area: 18a (Rolling Sagebrush Steppe) and 18e (Salt Desert Shrub Basins). The approximate boundaries of these two ecoregions within the project area are shown in **Map 3.6-1**.

Ecoregion 18a is described as a semiarid, vast region of rolling plains, alluvial and outwash fans, hills, cuestas (a ridge with a gentle slope on one side and a cliff on the other), mesas, and terraces. Average annual precipitation in this ecoregion ranges from 10–12 inches depending upon elevation and proximity to mountains. The dominant vegetation in this ecoregion is sagebrush (*Artemisia* spp.), often associated with various wheatgrasses (*Agropyron* spp.) or fescue (*Festuca* spp.). Elevation, aridity, slope, aspect, snow accumulation, prevailing winds, and other factors all affect the species composition, morphology, and density of sagebrush communities in the ecoregion. Ecotones between sagebrush steppe and adjacent mountain ecoregions may appear at elevations as high as 9,800 feet (Omernik 1987). The ecoregion is also interspersed with desert shrublands, dunes, and barren area in more arid regions (e.g., Red Desert); and with mixed-grass prairie at the eastern limit of the ecoregion (Knight 1994). Streams originating in the center of the basin are usually incised with a low gradient with fine gravel substrates derived from shales. Small streams are ephemeral or weakly intermittent with sand or platy shale substrates (EPA 2003, 2004).

The Salt Desert Shrub (18e) ecoregion includes disjunct playas and isolated sand dunes. The plains, terraces, and rolling alluvial fans of Ecoregion 18e have soils that tend to be more alkaline and less permeable than soils in the Rolling Sagebrush Steppe (18a). Vegetation is a sparse cover of xeric-adapted species such as shadscale (*Atriplex confertifolia*), greasewood (*Sarcobatus vermiculatus*), and Gardner's saltbush (*Atriplex gardneri*). Areas with stabilized sand dunes are dominated by alkali cordgrass (*Spartina gracilis*), Indian ricegrass (*Achnatherum hymenoides*), blow-out grass (*Redfieldia flexuosa*), alkali wildrye (*Leymus simplex*), and needle-and-thread (*Hesperostipa comata*). This arid region is sensitive to grazing pressure, which may promote the spread of invasive weeds such as Russian thistle (*Salsola kali*), cheatgrass (*Bromus tectorum*), and halogeton (*Halogeton glomeratus*). Land use is primarily rangeland and wildlife habitat (Omernik 1987). Streams are incised and flow into playa areas which are usually seasonal and have high levels of soluble salts (e.g., Chain Lakes area). Substrate is commonly fine-textured material or platy shale gravels (EPA 2003, 2004).



Map 3.6-1. General location of Level IV Ecoregions within the CD-C project area

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

3.6.2 Primary Cover Types

Native plants in the project area are predominantly drought-tolerant low shrub, grass, and flowering forb species that are generally distributed according to the biological, chemical, and physical properties of the parent soils of the area, as well as elevation, slope, aspect, and water availability.[9]

Fourteen primary cover types were identified and classified in the project area using the digitized data that were field-verified throughout the 2007 growing season. Ten of the 14 cover types are vegetation cover types and the remaining four are non-vegetated (bare ground, water, rock or talus slopes, and playas). **Table 3.6-1** shows the GIS-derived acreage of each vegetation and non-vegetated cover type. The distribution of the various cover types on the project area is shown on **Map 3.6-2**.

Table 3.6-1. Primary cover types within the project area

Primary Cover Type	Acres	Percent of Total Project Surface Area
Wyoming Big Sagebrush	417,572.7	39.00
Greasewood flats and fans	246,272.7	23.00
Saltbush flats and fans	172,698.7	16.10
Mixed desert shrub	142,062.6	13.30
Mountain Big Sagebrush	54,605.9	5.10
Basin Big Sagebrush	7,157.1	0.70
Basin grassland	5,122.2	0.50
Bare ground	4,117.5	0.40
Water	2,128.5	0.20
Rock or talus slope	1,033.9	0.10
Riparian/wet meadow	1,003.7	0.10
Juniper woodland	536.0	0.05
Vegetated sand dunes	275.5	0.03
Playa	124.3	0.01

Extended drought conditions throughout southwestern and south-central Wyoming have adversely impacted many native shrub communities and several drought-related die-backs and die-offs are evident throughout the project area. The greatest mortality appears to occur in *Artemisia* species and subspecies that are more adapted to mesic sites, e.g., basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*) (ATT) and mountain big sagebrush (*A.t.* spp. *vaseyana var. vaseyana* and *var. pauciflora*). The majority of shrub mortality appears to be localized within and along the many draws (e.g., Barrel Springs Draw, Red Wash Draw) and ephemeral drainages within the project area that, in a normal precipitation year, retain enough moisture through the summer months to support the water requirements of these taxa. The more xeric-adapted Wyoming big sagebrush (*A.t. wyomingensis*) (ATW) subspecies and Gardner's saltbush (*Atriplex gardneri*) communities have been least affected. However, many ATW plants exhibit individual stem death which is common for this subspecies under severe moisture stress (Fisser 1987). With the exception of the 2007 growing season, seed production of ATW and Gardner's saltbush has been minimal over the past six to seven years as a result of drought stress. Plant mortality is also evident in several greasewood (*Sarcobatus vermiculatus*) and shadscale stands in the southern portion of the project area (e.g., south of I-80).

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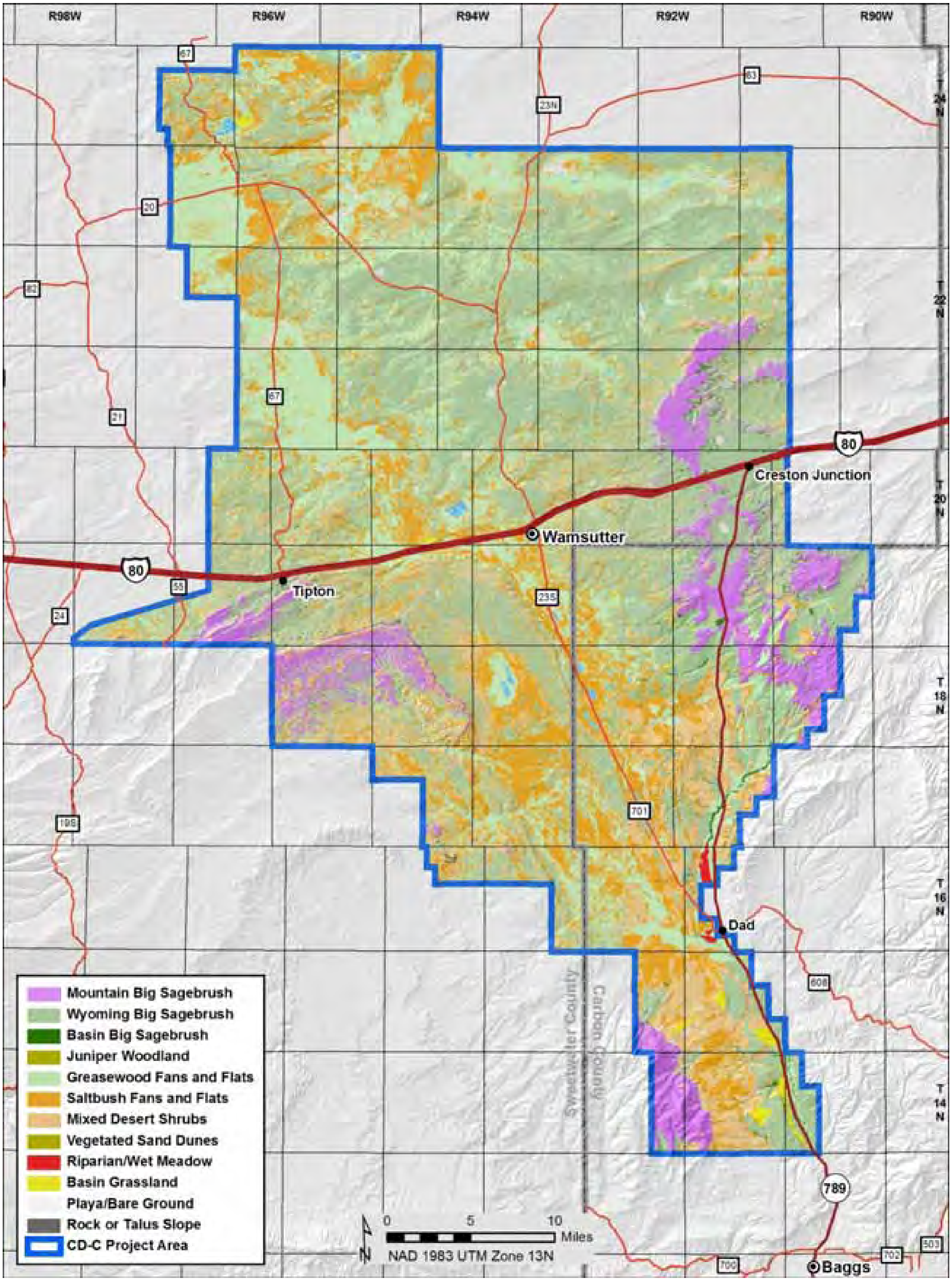
[9] The baseline data for the primary vegetation cover types were provided by Aero-graphics, Inc. (Salt Lake City, UT). The sub-meter aerial photographs were acquired with a fixed-wing aircraft flying at an altitude of 12,000 feet above ground level during the week of June 19–23, 2006. The aerially-acquired data were digitized and ortho-rectified by Aero-graphics. The final digitized data were processed by Hayden-Wing Associates LLC using ArcGIS® Version 9.1.



Map 3.6-2. Major land cover types within the CD-C project area

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

3.6.2.1 Mountain Big Sagebrush Cover Type and Subtype Inclusions

In the past, studies have identified *Artemisia tridentata* spp. *vaseyana* as mountain big sagebrush. However, recent investigations (Goodrich *et al*. 1999, Tart and Winward 1996) recognize two varieties of this subspecies, *vaseyana* and *pauciflora*. Numerous field investigations by Hayden-Wing Associates LLC (HWA) throughout Wyoming have found these two varieties are morphologically similar in growth form and are usually intermixed in the same habitat. Therefore, in the project area, these two varieties have been mapped as one type and will be hereafter referred to as mountain big sagebrush (ATVP). ATVP occupies approximately 54,606 acres within the project area, or about 5.1 percent of the project's total land surface area (**Table 3.6-1**).

Throughout the Intermountain West, ATVP is found at elevations from 3,500–9,800 feet and occurs from foothills to subalpine zones. Annual precipitation ranges from 12–30 inches. Soils on which mountain big sagebrush grows range from slightly acid to slightly alkaline and are generally well-drained. Soil moisture is usually favorable throughout the growing season. A large number of grass, forb, and shrub species grow in association with this shrub and usually produce an abundance of forage. Open stands with good, diverse understory are essential to sage-grouse, and such sites can be used in treatment projects to maintain sufficient shrub density and cover for sage-grouse. It is essential that desirable understory species and woody species associated with mountain big sagebrush be retained or reestablished as part of the reclamation effort.

The lower-elevation range of ATVP on the project area is about 6,500–6,800 feet. ATVP plant density (stems per unit area) increases and plant form becomes more robust at about 6,900 feet. These attributes are more noticeable on the leeward side of north/south-oriented ridgelines and hogbacks where topographic features are favorable for extensive snow deposition and retention. The more robust stands appear to be closely associated with the higher elevations along the west rim of the Continental Divide which bisects the project area near Wamsutter, and in the Flat Top Mountain complex in the southern portion of the project area.

The southern and southwestern portions of the project area include the Flat Top Mountain complex (Flat Top Mountain, East Flat Top Mountain, North Flat Top Mountain, and West Flat Top Mountain) and Robbers Gulch areas, where higher elevations and a greater moisture regime provide suitable habitats for ATVP and mountain mixed-shrub communities. North Flat Top Mountain in the NW ¼ Section 2, T14N, R93W is the highest topographic feature in the project area with an altitude of 7,822 feet. It is at these greater elevations with deeper soils that ATVP can grow to over 40 inches tall and become so dense that it is difficult to walk through the stand.

Common grass species associated with the ATVP cover type include:

- Bluebunch wheatgrass (*Pseudoroegneria spicata*)
- Bottlebrush squirreltail (*Elymus elymoides*)
- Green needlegrass (*Nassella viridula*)
- Idaho fescue *(Festuca idahoensis)*
- Little bluegrass (*Poa secunda*)
- Mutton bluegrass (*Poa fendleriana*)
- Needle-and-thread (*Hesperostipa comata*)
- Oniongrass (Melica bulbosa)
- Prairie junegrass (*Koeleria cristata*)
- Spike fescue (*Leucopa kingii*)
- Thickspike wheatgrass (*Elymus macrourus*)

Common understory shrubs may include green (Douglas) rabbitbrush (*Chrysothamnus viscidiflorus*), gray (rubber) rabbitbrush (*Ericameria nauseosa*), and snowberry (*Symphoricarpus oreophilus*), with lesser densities of antelope bitterbrush (*Purshia tridentata*) and serviceberry (*Amelanchier alnifolia*). The increased average annual precipitation at these ATVP sites provides suitable habitat for a diverse and abundant forb component. Frequently observed forb species include the following:

- Arrowleaf balsamroot (*Balsamorhiza sagittata*)
- Beardtongue (*Penstemon* spp.)
- Bluebells (*Mertensia* spp.)
- False dandelion (*Agoseris glauca*)
- Geranium *(Geranium richardsonii)*
- Groundsel (*Senicio* spp.)
- Indian paintbrush (*Castilleja* spp.)
- Phlox *(Phlox multiflora)*
- Sego lily *(Calochortus nuttallianum)*
- Silky lupine (*Lupinus sericeus*)
- Sulphur buckwheat (*Eriogonum umbellatum*)
- Wild onion (*Allium* spp.)

The mixed mountain-shrub cover type is similar to the mountain big sagebrush described above, with the distinction that mountain-shrub species must comprise 5 percent or more of the canopy cover to be classified as a mixed mountain-shrub cover type. Mixed mountain-shrubs occur in the Flattop Mountain complex, especially on the north and east aspects, but ATVP is the dominant shrub species at all these locations.

Chemical treatment of late successional, dense stands of ATVP in the project area has been conducted by the RFO to reduce sagebrush density and increase herbaceous production. Thinning of ATVP with low rates of the herbicide tebuthiuron has been demonstrated to enhance herbaceous plant production, community structure, ecosystem functioning, and biodiversity (Olson and Whitson 2002). The concept of sagebrush “thinning” was developed at the University of Wyoming and has been shown to have broad applications in rangeland environments, including restoration projects.

Wildfires and prescribed fires both occur in the ATVP cover type. Mountain big sagebrush is highly susceptible to injury from fire, and plants are readily killed in all seasons, even by light-severity fires (Blaisdell 1953, Blaisdell *et al*. 1982, Neuenschwander 1980). Without rest or post-burn grazing management, sagebrush cover may return to pre-treatment levels. Lesica *et al*. (2007) examined 38 sites in southwestern Montana and found that average post-fire time to full recovery for mountain big sagebrush was about 32 years. Monitoring of prescribed burns of ATVP with rest or deferment after burning in Carbon County indicates sagebrush recovery may take up to 50 years to reach pre-burn levels (Warren 2004).

3.6.2.2 Wyoming Big Sagebrush Cover Type and Subtype Inclusions

Wyoming big sagebrush (ATW) is the dominant vegetation cover type in the project area and occupies approximately 417,572 acres or about 39 percent of the project’s total land surface area (**Table 3.6-1**). The ATW subspecies can be found throughout the Intermountain West on xeric sites, foothills, valleys, and mesas between 2,500 and 7,000 feet. Annual precipitation varies from 7–15 inches. Soils on which ATW occur are usually well-drained, gravelly to stony, and may have low water-holding capacity. Soils are shallow, usually less than about 18 inches deep. Fewer herbaceous species are associated with Wyoming big sagebrush than with ATT or ATVP. Native bunchgrasses are often important understory species in ATW communities.

ATW occurs in almost an infinite number of communities and associations. Since the plants are almost totally dependent upon moisture received through infiltration and percolation of snow or rain water, their size and productivity responds as a direct result to moisture availability as influenced by soil, chemical, or other site criteria. The ATW communities with vigorous and productive plants are often located in depressions/swales protected from wind. These sites have a relatively deep and porous soil. Open, wind-blown sites normally have a thin, A Horizon topsoil layer. The plants are sparse, small in stature, and exhibit limited productivity. Fisser (1972) identified three recognizable ATW sub-community classifications based on obvious plant heights:

1. Arid – average height about 10–12 inches;
2. Intermediate – average height about 12–18 inches; and
3. Mesic – average height about 18–24 inches.

Healthy and vigorous ATW plants located in ideal growing sites can attain a height of 40 inches.

An estimate of the elevation range for ATW in the project area indicates it is the dominant sagebrush subspecies below an elevation of about 6,500 feet. This elevation is about the same as the lower-elevation limit of ATVP. Therefore, it becomes apparent that in most cases, the transition zone between these two taxa is not well-defined and may occur over a distance of several miles depending mainly on parent-soil characteristics, snow-deposition patterns, slope, and aspect.

The most common grasses associated with the ATW cover type include the following:

- Bottlebrush squirreltail
- Indian ricegrass *(Achnatherum hymenoides)*
- Little bluegrass
- Needle-and-thread
- Thickspike wheatgrass
- Western wheatgrass (*Pascopyrum smithii*)
- Threadleaf sedge (*Carex filifolia*)

Other shrubs often associated with this cover type are typically as follows:

- Broom snakeweed *(Gutierrezia sarothrae)*
- Cotton horsebrush (*Tetradymia canescens*)
- Gray rabbitbrush
- Green rabbitbrush
- Shadscale
- Spiny hopsage (*Grayia spinosa*)
- Plains prickly-pear cactus (*Polyacantha opuntia*)
- Winterfat *(Krascheninnikovia lanata)*

Forbs are less common than in other sagebrush communities due to the more arid environment. However, the most frequently observed species include the following:

- Beardtongue (*Penstemon* spp.)
- Goldenweed (*Happlopappus* ssp.)
- Hood’s phlox (*Phlox hoodii*)
- Hollyleaf clover *(Trifolium gymnocarpum)*
- Hooker’s sandwort (*Arenaria hookeri*)
- Locoweeds (*Oxytropis* spp.)
- Long-leaf phlox (*Phlox longiloba*)
- Low buckwheat *(Erigonum ovalifolium)*
- Spring parsley (*Cymopterus acaulis*)
- Wild onion (*Allium* spp.)

An *Artemisia* taxon closely related to ATW (Winward 1991a) was identified north of the Chain Lake Flats area. This currently undescribed taxon is tentatively known as Gosiute big sagebrush and is thought to be a hybrid between ATW and ATV var. *pauciflora* (Winward 1999). The distribution of this hybrid *Artemisia* is believed to be closely associated with the shoreline soils of the ancient paleolake Gosiute in Wyoming (Winward 1999). A map of the approximate shoreline of Lake Gosiute during the Eocene (Dyni 1996) indicates the eastern extent of its shoreline was approximately near Creston Junction and extended northwest into Sweetwater County, crossing the Chain Lakes area. At its maximum extent, Lake Gosiute covered about 15,000 mi^2 (Dyni 1996). Gosiute big sagebrush has many unique characteristics that are described more fully by Bennett (2004).

On gravelly to rocky, shallow sites, both bluebunch wheatgrass and black sagebrush (*A. nova*) are found in addition to a greater density of cushion plants. This subtype inclusion may be observed at certain locations along Red Creek Road in the northern portion of the project area. The black sagebrush present is the light form of the genus. Other sub-type inclusions in the ATW cover type include small, open areas dominated by bud sagebrush (*Picrothamnus desertorum*) such as that found on the plateau area north of Lost Creek Basin. The most diverse ATW sub-type inclusions observed are associated with the many small, stabilized sand dunes that occur in the western and northern portions of the project area. These dunes are associated with similar dunes found in the Sand Hills, Ferris Mountains, and the Killpecker Sand Dune areas. When the dune is oriented perpendicular to the westerly winter wind, it is not uncommon to observe arid-adapted species such as ATW, spiny hopsage, and prickly-pear cactus on the western aspect of the dune slope and mesic forms such as basin big sagebrush and greasewood on the leeward side where snow deposition provides greater water availability. The dune sites with the greatest vegetation diversity occur near the south shore of the several small lakes in the Chain Lakes area where it is not uncommon to observe budsage, ATW, Wood's rose, shadscale, spiny hopsage, fringed sage (*A. filifolia*), greasewood, and green rabbitbrush growing together, intermixed with grasses and forbs in a very small area.

The value of ATW as an important winter browse species cannot be overemphasized. Mule deer preference for sagebrush species as winter forage is well-documented (Sheehy and Winward 1981, Wambolt 2004). Nelson *et al*. (1994) found that ATW in the winter diets of mule deer in the Baggs Habitat Unit comprised approximately 74 percent of the total diet. DeBolt (2000) found ATW made up more than 70 percent of mule deer diets on winter ranges west of WY 789. ATW is also an important food item for greater sage-grouse (*Centrocercus urophasianus*) and taller stands have been shown to serve as severe winter relief (SWR) habitat for these birds during winters of record-breaking snowfall such as occurred during the winter of 2000–01 (HWA 2004) and 2010–11 (WRCC 2012).

The sagebrush "thinning" concept discussed in the mountain big sagebrush sub-section (**3.6.2.1**) has also been employed by the RFO to reduce ATW density and increase herbaceous production in the Tipton and Flattop areas of the CD-C project area.

Wildfire is not common in the ATW cover type due to the low quantity of fine fuels in the shrub's interspaces that can support and carry a fire. However, in extreme weather conditions (e.g., low humidity, high temperatures, and strong winds) such as was common during the 2000 fire season, fire was observed to carry rapidly through a sparse ATW stand west of Medicine Bow, Wyoming (Bennett 2004).

Following fire or other major disturbance, herbaceous species will dominate the treatment site and recovery to 20 percent canopy cover may take more than 40 years (Young and Evans 1989, Winward 1991b). Site reestablishment is by seed bank, seed production from remnant plants, and seeds from adjacent plants outside of the burn area. Discontinuity of fuels in ATW communities usually results in mosaic burn patterns, leaving remnant plants for seed (Bushey 1987). Overall fire return intervals in ATW appear to have ranged from 10–240 years or more (Winward 1991b, Bunting *et al*. 1987, Young and Evans 1989). Reviewers for the Rapid Assessment Reference Condition Model component of the LANDFIRE project (www.landfire.gov) disagreed about average fire-return intervals in the ATW vegetation group, but agreed the mean fire intervals of 90–140 years were probably realistic (Schmidt *et al*. 2002).

3.6.2.3 Basin Big Sagebrush Cover Type

Basin big sagebrush (ATT) occupies approximately 7,157 acres within the project area or about 0.7 percent of the project's total land surface area (**Table 3.6-1**). ATT typically occurs on the deeper, well-drained soils usually found along ephemeral and intermittent drainages, floodplains, and leeward slopes where water availability is greater than on adjacent uplands. It is often co-dominant with greasewood at certain sites and may occur as small inclusions in the ATW and ATVP cover types. Bennett (2004) found that heights of ATT are a good measure of site suitability. More arid sites produce plants that average about 23 inches in height, intermediate sites about 29 inches and mesic sites greater than 62 inches. At ideal sites such as found along the Muddy Creek drainage, ATT often grows to 10 feet in height, and plants attaining 13 feet in height have been recorded along the Green River in Sublette County (Bennett 2004). Palatability of ATT is generally considered lower than ATW (Rosentreter 2005). This phenomenon was observed by the Rawlins BLM staff during the harsh winter of 1983–84 in the Muddy Creek area. They found that mule deer use of ATW was severe compared to marginal use of ATT, even though animals were starving and winter mortality reached 50 percent in some Herd Units (Warren 2004).

Common understory species in the ATT cover type include the following:

- Aster
- Basin wildrye (*Leymus cinereus*)
- Bluebell
- Buttercup
- False dandelion
- Golden currant (*Ribes aureum*)
- Gray rabbitbrush
- Green rabbitbrush
- Kentucky bluegrass (*Poa pratensis*)
- Little bluegrass
- Locoweed
- Lupine
- Louisiana sagewort (*A. ludovicianna*)
- Povertyweed (*Iva axillaris*)
- Snowberry
- Thickspike wheatgrass
- Violet
- Wild onion
- Wood's rose (*Rosa woodsii*)

Wildfires and prescribed burns both occur in this cover type. Where other species are uncommon or without post-burn grazing management, sagebrush cover may return to pre-treatment levels in 15–20 years. However, monitoring of prescribed burns with rest or deferment after treatment indicate ATT recovery may take up to 50 years to attain pre-treatment levels.

The recent prolonged drought in south-central Wyoming has had a severe effect on ATT. The majority of the sagebrush die-backs and die-offs observed at present in the project area occur in ATT and ATVP stands, both of which depend on perennial mesic conditions for growth, reproduction, and survival. The heaviest mortality has been observed to occur along ephemeral channels in heavier soils where water availability is usually good to excellent in normal years. The most robust plants are currently associated with higher-elevation sandy loam soils on the leeward (usually east) side of slopes where snowdrifts accumulate, thereby increasing water availability. The same beneficial effect can be seen on the leeward side of the many snow fences in the project area, especially along I-80 and WY 789.

3.6.2.4 Juniper Woodland Cover Type

The juniper woodland cover type occupies about 536 acres on the project area or about 0.05 percent of the project's total land surface area (**Table 3.6-1**). Utah juniper (*Juniperus osteosperma*) is the dominant tree within this cover type. The preferred habitat of Utah juniper is usually associated with shallow, rocky soil with a fractured rock substrate, where the tree can root down to and take advantage of collected water. Juniper will also encroach into adjacent sagebrush stands. This can be seen west of the Bluffs in the extreme southern end of the project area, north of Baggs along the west side of WY 789. In April 2007, several hundred mule deer were seen daily on the cuesta west of the bluffs. They appeared to be using the tree area for bedding and thermal cover during the day and then trailing down the slopes to the Muddy Creek drainage for food and water at night. The dominant sagebrush taxon on the cuesta is ATVP, which is ranked as more palatable than ATW and ATT (Rosentreter 2005).

Common understory species associated with this cover type include the following:

- Beardtongue
- Bitterbrush
- Black sagebrush
- Bluebunch wheatgrass
- Canby bluegrass (*Poa canbyi*)
- Goldenweed
- Groundsel
- Indian ricegrass
- Little bluegrass
- Miner's candle (*Cryptantha* ssp.)
- Phlox
- Twin bladderpod (*Physaria* ssp.)

When stands of Utah juniper become too dense, the understory of native grasses and forbs dies out and is usually replaced by invasive species such as downy brome (*Bromus tectorum*) and annual forbs. Fire can be a useful tool in reducing juniper overstory and maintaining understory cover and composition. Where the understory is too sparse to carry a fire, some form of mechanical treatment may be required to restore species diversity. A great number of Utah juniper in this area were logged to produce charcoal for the Union Pacific Railroad (UPRR) smelters in Rawlins in the 1870s–80s (Bennett 2004).

3.6.2.5 Greasewood Flats and Fans

The greasewood cover type occupies approximately 246,273 acres within the project area or about 23 percent of the project's total land surface area (**Table 3.6-1**). Greasewood is a native, deciduous perennial shrub and can attain heights of 8 feet under ideal growing conditions.

Greasewood inhabits a wide range of plant communities within the project area. Plants are typically found growing in saline soils that can be quite moist (wet saline meadows) to dry uplands. Greasewood is often the dominant species in the plant community, but plants are also found associated with saltbush, saltgrass, shadscale, and ATT and ATW sagebrush communities. Ideal habitat for greasewood within the project area is often located on saline valley bottoms (e.g., Muddy Creek floodplain) and on salt-bearing shale outcrops in canyons and on foothills. Sites vary in respect to soil texture and availability of groundwater. Some sites are wet with high water tables, and others are dry with well-drained soils. Greasewood occurs in the project area as smaller, mixed stands to large, monotypic stands. The latter were observed in several large saline basins located in the northern portion of the project area (e.g. Lost Creek and Red Desert Basins). Greasewood can be found at all elevations of the project area. It often encroaches into the big sagebrush and saltbush cover types, especially where additional moisture is available, such as on the many vegetated sand dunes in the southwestern portion of the project area (e.g., north of Mexican Flats).

Greasewood is the dominant shrub associated with the large, vegetated sand-dune complex extending west to east across the northern portion of the area. The most extensive vegetated dune complex is located in T23N:R97W and T23N:R96W. Within this complex, several active dunes are also present. The established greasewood in this sandy area serve as a valuable soil stabilizer by decreasing wind and water erosion. Black greasewood is also the dominant shrub species in the Chain Lakes region in the northern portion of the project area. An unusual greasewood growth form was observed in the vicinity of the several small lakes in this area. The usual upright stature of the plant has been replaced by a low, prostrate, spreading form which rarely exceeds 10–12 inches in height. It is unknown at the present time if this is an ecotypic adaptation or if the plants represent a different subspecies. Greasewood distribution and abundance in the southern portion of the project area is greatest along portions of the Muddy Creek floodplain corridor and in a large, flat basin immediately north of the Mexican Flats area.

The palatability of greasewood in Wyoming is reported as fair for cattle, domestic sheep, horses, pronghorn, mule deer, and small mammals, and as poor for elk, white-tailed deer, small non-game birds and waterfowl (Dittberner & Olson 1983). Poisonous oxalates, found in the leaves, have caused mortality in sheep. Cattle are rarely poisoned, but spines are reported to puncture the rumen (the first chamber of the alimentary canal). Greasewood understory composition is not as diverse as in the big sagebrush cover types.

Common understory species in the black greasewood cover type include the following:

- Basin wildrye
- Biscuitroot
- Bottlebrush squirreltail
- Gardner's saltbush
- Inland saltgrass (*Distichlis spicata*)
- Little bluegrass
- Western wheatgrass
- Wild onion

3.6.2.6 Saltbush Flats and Fans and Sub-type Inclusions

Gardner's saltbush (saltbush) is a native, spreading, low-growing, evergreen perennial sub-shrub and grows from 8–20 inches in height (McArthur *et al*. 1978). Saltbush is the third-largest primary cover type on the project area following the ATW and black greasewood cover types at 172,699 acres or about 16 percent of the project's total land surface area (**Table 3.6-1**).

This cover type is found on saline soils in small to large openings or can occur as "stringer" inclusions within the ATW or greasewood primary cover types. These saltbush stands are sparsely vegetated and bare soil often exceeds 60 percent of the total ground-cover. Average vegetative stem height of saltbush on the project area ranges from 4–10 inches but several robust plants in the 16- to 18-inch range were observed south of the Chain Lakes area along Riner Road. Saltbush reproductive stems were observed to be particularly abundant during the 2007 growing season at all sites within the project area.

The largest monotypic saltbush communities within the project area are located in the Mexican Flats area. However, the northern portion of the project area also contains several sizable communities, and mountain plovers (*Charadrius montanus*) were observed at all locations where this cover type was dominant. The most common sub-type inclusion in this cover type is birdfoot sagebrush (*A. pedifidita*) which may occur as a pure stand or, more typically, intermixed with the saltbush plants.

The persistent leaves of saltbush provide nutritious winter forage for livestock and wildlife species throughout its range (Nord *et al.* 1969). It is particularly important for domestic sheep because it provides the minimum nutritional maintenance requirement for gestating ewes (Fisser & Joyce 1984).

Other common plant species associated with this cover type include the following:

- Biscuitroot
- Western wheatgrass
- Bottlebrush squirreltail
- Little bluegrass
- Indian ricegrass
- Plains prickly-pear cactus
- Threadleaf sedge (most common associate on the project area)
- Wild onion
- Winterfat

Commonly observed inclusions in the saltbush and desert shrub vegetation types are cushion plant communities. Cushion-plant vegetation is found on suitable sites scattered across much of the project area. In the cushion growth form, stems and leaves are densely aggregated near ground level, probably to reduce the stresses of severe environmental conditions (e.g. cold, high winds, desiccation). Cushion-plant vegetation has been divided into two broad categories—alpine and lowland—with completely different species compositions (Knight 1994). The lowland type is found on RFO lands.

According to Jones (2005), a “cushion-plant” is typically defined as a prostrate, acaulescent (having no stem or only a very short stem), tap-rooted forb that typically grows in a dense mat. Examples can be found in a number of plant families and include *Arenaria hookeri* (Caryophyllaceae), *Astragalus spatulatus* (Fabaceae), *Erigeron composites* (Asteraceae), *Eriogonum acaule* (Polygonaceae), *Draba oligosperma* (Brassicaceae), and *Phlox muscoides* (Polemoniaceae). Cushion-plant vegetation is the short, often sparse vegetation on rims and outcrops formed in resistant bedrock, where cushion-plants contribute a major proportion of the plant canopy cover. *Arenaria hookeri* and *Pseudoroegneria spicata* are almost always present in the cushion-plant vegetation and often contribute a substantial amount of the canopy cover. At many sites, these species are joined by *Phlox muscoides* (a cushion-plant) as a dominant or co-dominant. Elsewhere, *P. muscoides* is absent, and a number of other cushion-plants (*Astragalus spatulatus*, *Astragalus simplicifolius*, *Tetraneuris acaulis*, *Stenotus armerioides*) or non-cushion forbs (especially *Phlox hoodii*) are regularly present and sometimes contribute much of the canopy cover (Jones 2005).

The concept of cushion-plant vegetation usually excludes sparse vegetation dominated by non-cushion forbs or sub-shrubs (such as *Atriplex nuttallii* or *Artemisia pedatifida*) that occurs on soft bedrock. In the field, the Wyoming Natural Diversity Database (WYNDD) defines cushion-plant vegetation as vegetation in which cushion-plants are estimated to contribute at least 50 percent of the canopy cover and the grasses and shrubs common in the surrounding shrub-steppe vegetation contributes less than 50 percent of the canopy cover (Jones 2005).

3.6.2.7 Mixed Desert-Shrub

The mixed desert-shrub cover type occupies approximately 142,062 acres on the project area or about 13 percent of the project’s total land surface area (**Table 3.6-1**). The mixed desert shrub cover type as described in this document is a mixture of shrubs and sub-shrubs occurring in dry, saline upland habitats.

Shrub cover is often dominated by shadscale but can be a mixture of saltbush, black greasewood and/or desert cushion plants. Several small sites were observed in the northern portion of the project area along Red Creek Road where bud sage (*Picrothamnus desertorum*) is the dominant shrub with plants reaching 10 inches in height with a robust form which is unusual for this species in Wyoming. A herbaceous understory of forbs and grasses is usually present within this cover type and biological soil crusts are usually present on the soil surface. This cover type exhibits three phases including: (1) sites dominated by sagebrush, (2) sites dominated by saline-tolerant shrubs such as greasewood and saltbush, and (3) discontinuous areas devoid of woody shrubs, but with the same herbaceous understory components characteristic of shrub-covered areas. As with the saltbush vegetation cover type, cushion plant communities are often observed in the mixed desert shrub cover type.

Common herbaceous ground-cover species in desert shrub communities include the following:

- Bluebunch wheatgrass
- Buckwheat
- Common yarrow *(Achillea millefolium)*
- Indian paintbrush (*Castilleja* spp.)
- Indian ricegrass
- Needle-and-thread grass
- Plains prickly-pear
- Sandberg bluegrass
- Threadleaf sedge
- Western wheatgrass

In addition to sagebrush, other shrubs commonly observed in this cover type often include the following:

- Gray rabbitbrush
- Green rabbitbrush
- Shadscale
- Spiny hopsage
- Spiny horsebrush

3.6.2.8 Vegetated Sand Dunes

Vegetated sand dunes occupy approximately 276 acres within the project area, or about 0.03 percent of the project's total land surface (**Table 3.6-1**). The largest sand-dune complex in the project area is in the northern portion of the project area and primarily located in T23N:R97W and T23N:R96W in Sweetwater County, north of County Road (CR) 67 and CR 20. Several dunes in this complex are currently active and vegetation is absent. Many smaller, vegetated dune sites are located throughout the west-central portion of the project area west of Dad and near the southern edge of the Chain Lakes area. Greasewood is the dominant shrub on many of these dunes and serves as a valuable soil stabilizer by decreasing wind and water erosion. A recent investigation of the Killpecker sand dune area in southwest Wyoming by Mayer and Mahan (2004) found that the age of eolian sand (15,000 years before present [B.P.]), combined with those of Folsom (12,950–11,950 years B.P.) and Agate Basin artifacts (12,600–10,700 years B.P.) overlying eolian sand, indicates the dune field existed at least during the late Pleistocene.

These unique sites provide micro-environments that allow for greater plant diversity than adjacent upland sites. Steidtmann (1973) found that snow may become incorporated in eolian sand dunes of southwestern Wyoming when snow cornices on dune crests begin to melt, slide down the lee slope, and are covered by sand during subsequent lee-slide deposition. In some cases burial is rapid enough to provide the insulation necessary to preserve the ice and snow within the dune throughout the year. The smaller dunal areas such as those found west of Dad are predominantly oriented perpendicular to the westerly prevailing winter wind, forming natural snow-breaks that trap snow on their leeward side. It is not uncommon to observe ATW (arid form), spiny hopsage, and prickly-pear cactus on the western aspect and ATW (mesic form), ATT, and greasewood on the leeward side of these smaller, stabilized sand dunes.

The small dune sites south of the Chain Lakes complex often occur within other primary cover types (e.g., ATW and saltbush) and form hummocks covered with a diverse shrub and herbaceous understory very different than the surrounding vegetation. At several sites it was observed that a combination of budsage, ATW, shadscale, spiny hopsage, fringed sage, greasewood, and green rabbitbrush intermixed with grasses and forbs were all occupying these small hummocks.

3.6.2.9 Riparian Cover Types

The riparian/wet-meadow cover type occupies about 1,004 acres on the project area or about 0.10 percent of the project's total land surface area (**Table 3.6-1**). Riparian sites often occur as narrow corridors traversing many different plant zones. Streams and drainages often occupy very small but important sites within major land types. The vegetation and habitat provided by the riparian zone is extremely important to the management of associated lands. Riparian sites attract and sustain livestock and wildlife and are particularly important during the midsummer months. The recent extended drought has concentrated the use of riparian sites by livestock, wildlife, and wild horses—usually with deleterious effects. The two allotments that did not meet Standard # 2 (Riparian/Wetland Health) of the Standards for Public Land Health (See **Section 3.6.3**.) were the Cyclone Rim (10103) and Jawbone (00709) allotments. The Cyclone Rim allotment failed the Standard because of non-functional or Functioning-At-Risk springs and seeps. Identified causes included previous excessive use by wild horses during the growing season, often complicated by livestock grazing (BLM 2001a). There is only one permanent water source (Mud Springs) in the Jawbone allotment (23,000 acres/9,307 ha.) in addition to one well and ten semi-reliable reservoirs. Summer cattle use was identified as the primary factor affecting the wetland habitat/vegetation in this allotment. Since the 1998-2000 PFC evaluations, fencing and off-site water development have been installed at many of these sites (BLM 2001a).

Riparian communities often provide diversity to otherwise rather barren and exposed wildlands. Riparian habitat within the project area occurs along perennial and intermittent drainages, around seeps and springs, and around man-made reservoirs. Although small in extent, these areas are the most productive of all vegetation types and therefore are extremely important for wildlife habitat and livestock forage.

The major drainage in the southern portion of the project area is Muddy Creek (HUC 14050004). Muddy Creek is described as a high-elevation, cold-desert stream originating in the Sierra Madre Range east of the project area and terminating at its confluence with the Little Snake River near Baggs, Wyoming. Upstream from this confluence, numerous unnamed ephemeral channels and named draws flow into Muddy Creek.

The northern portion of the project area generally drains into the Great Divide Basin (HUC 14040200) via Separation Creek. The Great Divide Basin is a closed basin bounded by the Continental Divide on all sides and has no hydrologic outlet (Seaber *et al*. 1987). The Great Divide Basin is a relatively shallow depression with isolated buttes, pan-like depressions, and sparse vegetation. Numerous ephemeral streams flow toward the center of the Basin before disappearing into the soil or man-made impoundments. The Chain Lakes complex is located approximately 32 miles northwest of Rawlins. Two large lakes and several small lakes extend from west to east across the flats. This general area supports greater sage-grouse, migratory waterfowl, and shorebirds, and provides winter habitat for pronghorn. Small bands of wild horses from the Lost Creek Herd Management Area (HMA) are commonly observed in this part of the project area.

Riparian/wetland habitat within the project area can be defined and described in the following groups: desert springs and seeps, and streams supported by them; playa lakebeds; wetlands in the Chain Lakes area; and man-made wetlands around artesian wells. Streams in the area generally flow short distances supporting riparian vegetation before turning into ephemeral/intermittent drainages that do not support riparian vegetation. A good example is Lost Creek which is fed by Eagle's Nest Spring. Riparian conditions exist above the Red Creek Road culvert before the stream disappears underground. However, from the culvert and continuing to Lost Lake, the creek's stream bed is normally dry and its riparian corridor supports mainly greasewood and non-riparian vegetation. The Lost Creek drainage corridor was observed to provide excellent pygmy rabbit habitat and appears to be a major travel route and bedding area for elk from the Red Desert Migratory Elk Herd. Three to seven head of elk were consistently seen in this area during Apri – May, 2007. The Lost Creek streambed below Eagle's Nest Spring was documented by HWA to contain persistent sepal yellowcress (*Rorippia calcycina*), a BLM-designated special status plant species. The 2006 and 2007 HWA special status plant species survey results are available as a separate Technical Report (HWA 2008a).

Riparian grassland habitat types are the most common forms of vegetation found within riparian areas in the project area. Riparian grasslands are wetland-, stream-, or spring-associated grass and grass-like communities, which are maintained by a water table within rooting depth during most of the growing season. Common species include the following:

- Alkali sacaton *(Sporobolus airoides)*
- Asters
- Baltic rush *(Juncus balticus)*
- Basin wildrye
- Beaked sedge (*C. utriculata*)
- Cinquefoil *(Dasiphora floribunda)*
- Horsetail *(Eqisetum arvense)*
- Inland saltgrass (*Distichlis spicata*)
- Kentucky bluegrass
- Liddon sedge (*C. petasata*)
- Mat muhly *(Muhlenbergia richardsonis)*
- Mint (*Mentha* spp.)
- Nebraska sedge (*Carex nebrascensis*)
- Redtop *(Agrostis stoloifera)*
- Spike sedge (*C. nardina*)
- Thistle
- Tufted hairgrass *(Deschampsia caespitosa)*
- Wheatgrass

The majority of the project area consists of ephemeral drainages (washes, draws, gullies) which flow only in response to snowmelt in early spring or as a result of summer precipitation events which are usually of short but intense duration. Soil erosion may be severe where erosion devices are not present or ground cover is sparse.

The most prominent natural wetland system in the northern portion of the project area is the Chain Lakes complex. These lakes and adjacent habitats support riparian grassland and open aquatic-emergent wetland habitats. Within these alkaline wetlands, the shallow pools where salts accumulate are the harshest growing environment for plants. Plants must tolerate not only standing water in spring, but also dry and extremely alkaline soils in late summer. Stunted, scattered plants of arrowgrass (*Triglochin* spp.), an exceedingly salt-tolerant, grass-like forb, are frequently the sole inhabitants of these highly alkaline depressions. Alkali plantain (*Plantago eriopoda*) and inland saltgrass can survive in less alkaline depressions. Like most halophytes (plants adapted to grow on salty soils) these plants have the ability to accumulate higher concentrations of salts in their cell sap than salt concentrations in the soil water. By concentrating salts, these halophytes can draw soil water into their roots, since water generally flows from areas of low salt concentration to areas of higher salt concentrations

Plant species in these areas are saline/alkali tolerant and may include:

- Alkali plantain
- Alkali saltgrass (*Distichlis stricta*)
- American bulrush *(Schoenoplectus americanus)*
- Arrowgrass
- Baltic rush
- Buttercup
- Cinquefoil (*Potentilla* spp.)
- Greasewood
- Hairy goldaster *(Heterotheca villosa)*
- Nuttal's alkaligrass (*Puccinellia nuttalliana*)
- Rocky Mountain glasswort (*Salicornia rubra*)
- Sea milkwort (*Glaux maritima*)
- Slim sedge *(Carex praegracilis)*
- Tufted hairgrass *(Deschampsia caespitosa)*

The Chain Lakes wetlands also provide habitat for meadow milkvetch (*Astragalus diversifolius* var. *diversifolius*), recently discovered in 2008 by the WYNDD (Heidel 2008). The species has now been documented in three extant occurrences in south-central Wyoming, totaling approximately 8,000 plants within about 187 acres, near the Chain Lakes region of the project area (Heidel 2009) and was recently added to the BLM sensitive plant list (BLM 2010) (see **Section 3.9.2.3 Sensitive Plant Species**).

Man-made wetlands occur primarily next to artesian wells and reservoirs or pits. Wetlands supported by artesian wells are mostly composed of sedges, bulrushes, and several grass species. Many reservoirs and pits in the project area do not hold water on a year-long basis and the perennial drought that began with the 2000 growing season has had negative effects on water-storage capabilities and wetland vegetation health.

An extensive wetland complex known as the George Dew/Red Wash Wetland Complex is located near Dad about 25 miles north of Baggs, west of and adjacent to WY 789. This site encompasses approximately 6 miles of willow-dominated (*Salix* sp.) riparian corridor along Muddy Creek with associated floodplain and meadows ranging from 0.25 to 0.75 mile wide, constructed and natural impoundments, and adjacent upland sites dominated by greasewood, sagebrush, and Gardner saltbush. The George Dew/state land wetlands project is within the Muddy Creek Wetland Complex. The wetland component of this project was designed to protect and enhance about 1,100 acres of existing wetlands and create 125 acres of new wetlands (Wyoming Riparian Association 1997).

3.6.2.10 Basin Grassland

The basin grassland vegetation cover type occupies approximately 5,122 acres within the project area or about 0.5 percent of the project's total land surface area (**Table 3.6-1**). This cover type is found in scattered park-like patches throughout the project area. Shrubs such as the native rabbitbrushes, winterfat, and various sagebrush species and subspecies may be present but cannot occupy more than 25 percent of the total ground cover to be classified as basin grassland. Herbaceous species often include western wheatgrass, blue grama, needle-and-thread, threadleaf sedge, Sandberg bluegrass, and prairie junegrass. Plains prickly-pear is also commonly observed in this cover type.

3.6.2.11 Non-vegetated Cover Type—Bare Ground

Bare ground on the project area accounts for approximately 4,117 acres or about 0.4 percent of the project's total land surface area (**Table 3.6-1**). Bare ground, as defined in this EIS, contains less than 7.5 percent vegetated ground cover. The soils in these relatively low-production areas and underlying parent materials are very soft and highly erosive, and the landscape is cut with a large number of drainage channels. Vegetation, if present in these sites, is sparse and may include various species ranging from stunted shrub forms to scattered bunchgrasses (e.g., Indian ricegrass and needle-and-thread).

3.6.2.12 Non-vegetated Cover Type—Water

This non-vegetated cover type occupies approximately 2,129 acres or about 0.2 percent of the project area (**Table 3.6-1**).

3.6.2.13 Non-vegetated Cover Type—Rock or Talus Slope

This non-vegetated cover type occupies approximately 1,034 acres or about 0.1 percent of the project area (**Table 3.6-1**), and includes naturally occurring areas of bare rock such as canyon cliffs, spires, rock outcrops, and talus fields.

3.6.2.14 Non-vegetated Cover Type—Playa

Playas occupy approximately 124 acres in the project area (**Table 3.6-1**). Playas are characterized as water catchments that are most often ephemeral, drain internally, accumulate sediment, and serve as recharge points to underground aquifers. While playas themselves are usually devoid of vegetation, they are commonly ringed by greasewood, shadscale, saltbush, and other salt-tolerant plants that provide critical winter forage for livestock and other herbivores. In Wyoming, playas, when flooded, are important sources of habitat for wildlife including waterfowl such as ducks and geese, along with sandhill cranes and shorebirds. Amphibians such as frogs, toads, and salamanders also depend on playas, as do several major orders of insects.

In most years playas are dry or water may only cover the lowest portion, the portion near a water source such as a spring, or the portion where an ephemeral stream discharges onto the playa surface. Between wet periods the surface of the playa typically dries out completely and may even become desiccated, forming polygonal cracks and fissures in clay-rich sediments. In playas where the groundwater table is at or near the surface, soluble salts will precipitate, forming ephemeral crusts that may or may not survive subsequent wetting episodes. The high salt and clay content of playa surface mud, and the dry and hot conditions that prevail most of the year, usually prevent plants from becoming established.

3.6.3 Watershed-Based Land Health Assessment

In 2008 the RFO finished conducting Standards and Guidelines Assessments for all the watersheds within the field office. These are watershed-based land health assessments mandated by the Director of the BLM on a 10-year basis. From 1998 through 2000, the RFO conducted Standards and Guidelines Assessments on an allotment basis; however, in 2001 to meet this 10-year timeframe, larger-scale watershed-based reports were undertaken. The Upper Colorado River and the Great Divide Basin were the first two watershed reports completed (2002 and 2003 respectively). Because these two watersheds were the first completed they are due for reassessment, at which time progress towards management objectives will be evaluated. Two of the standards apply to vegetation. Standard 2, Riparian and Wetland Vegetation, states that “riparian and wetland vegetation has structural, age, and species diversity characteristic of the stage of channel succession and is resilient and capable of recovering from natural and human disturbance in order to provide forage and cover, capture sediment, dissipate energy, and provide for groundwater recharge.” Standard 2 is considered to be met if riparian/wetland habitat is rated in Proper Functioning Condition (PFC) and existing management will lead to maintaining and/or improving resource conditions (BLM 2002).

Standard 3, Upland Vegetation, states that “vegetation on each ecological site consists of plant communities appropriate to the site which are resilient, diverse, and able to recover from natural and human disturbance.” Standard 3 is considered to be met if plant communities are sustaining themselves under existing conditions and management.

During the 2001 field season, project area watersheds within the Upper Colorado River Basin were assessed (BLM 2002). Results of the 2001 assessment indicated that Standard 2 – Riparian/Wetland Health, was being met by most allotments within the assessment area with the exception of 14 allotments, two of which are located in the project area (Cherokee 00408 & Red Creek 10521).

Most of the lentic and lotic sites that are not meeting the standard have been, or are in the process of being, addressed in management plans or as range improvement projects (BLM 2002). Assessment results for Standard 3 – Upland Vegetation Health, indicated that natural and ecological processes were functioning adequately for most vegetation communities. However, the review team had concerns about the uniformity of age classes in many shrub stands which may lead to over-maturity/decadence on a large scale if not properly managed. Shrub communities in this late-seral stage are particularly susceptible to large-scale die-offs due to many environmental and biological factors including drought, insect infestations, and disease.

3.6.4 Fugitive Dust Effects on Vegetation

The Environmental Protection Agency (EPA) states that the largest single source of fugitive dust in the U.S. is from unpaved roads which contribute about 10 million tons of particulate matter (PM) air pollution each year (EPA 1998). Dust from roads can contain very fine particles known as PM_{10} (particulate matter less than 10 microns in diameter) and $PM_{2.5}$ (particulate matter less than 2.5 microns in size). Ten microns equals about 1/7th the diameter of a human hair. Of greatest concern are the $PM_{2.5}$ particles that make up part of a dust cloud. Although PM and other air-quality issues are described more completely in **Section 3.5 Air Quality**, a brief discussion of the negative effects of fugitive dust on roadside/rangeland vegetation is presented in this section.

Dust deposits on plants can have important effects on plant life. These effects may include (but are not limited to):

- Reduced photosynthesis due to reduced light penetration through the leaf surface. This may cause stunting and/or reduced growth rates and plant vigor.
- Increased incidence of plant pests and disease. Dust deposits can act as a medium for the growth of fungal diseases.
- Reduced efficacy of herbicide sprays due to reduced penetration of the herbicide through the leaf surface.
- Reduced productivity and changes in community structure (the species of plants present) (Farmer 1993).
- Increased leaf temperatures and water loss, with decreasing carbon dioxide uptake (Eller 1977, Hirano *et al*. 1995, Ricks and Williams 1974, Fluckinger *et al*. 1979, Thompson *et al*. 1984).
- Decreased palatability and avoidance by wildlife and livestock.
- Increased tooth wear for herbivores.
- Greater biomass of annual plants within the dust-plume-affected area. Phenological differences (see **Glossary**) among the vascular plants are possibly due to differences in soil temperature on and off the dust-plume area early in the growing season (Spencer and Tinnin 1997).
- Susceptibility of vegetation in proximity to roads to chronic diseases affiliated with photosynthesis and growth, which may eventually lead to accelerated erosion problems from lack of adequate roadside vegetation, reduction in quality and quantity of available browse for livestock and wildlife, and creation of new sites for noxious weed infestations (Gebbhart and Hale 1996).
- Potential contamination of native wildflowers and their blossoms, altering patterns of pollen dispersal (and thus gene flow) among plants by altering the foraging behavior of pollinating insects. This impact could be important in habitats in proximity to unpaved roads occupied by USFWS or BLM special status plant species of concern.

GIS analysis of the road system within the project area indicates a total of about 5,736 miles of roads within the project's boundaries. This total includes: about 126 miles of paved roads (mainly I-80 and WY 789), about 2,055 miles of improved maintained exotic (e.g. graveled/rocked) roads, about 86 miles of improved maintained natural (e.g., natural surface) roads, and about 3,469 miles of unimproved, unmaintained natural (e.g., two-track) roads. These totals indicate that the total mileage of paved roads within the project area represents only about 2.2 percent of the total road system. **Section 3.16 Transportation and Access** describes the local and regional transportation network associated with the project area.

The primary factors that generate dust on unpaved roads include (Bolander 1999, Addo and Sanders 1993):

- Vehicle speed
- Number of wheels per vehicle
- Number of vehicles
- Vehicle weight
- Particle size distribution (gradation) of the surface material
- Restraint of the surface fines (compaction, cohesiveness/bonding)
- Durability of the road surface

A 1993 U.S. Department of Transportation study cites a 1983 Forest Service estimate that for every vehicle traveling one mile of unpaved roadway once a day, every day for a year, one ton of dust is deposited along a corridor extending 500 feet on either side of the roadway (Addo and Sanders 1993). In a study conducted in Australia, McCrea (1984) estimated the potential losses in crop productivity for various rates of dust deposition. The main focus of the report was on horticultural crops grown alongside unpaved roads, and in this case the losses occurred within about 656 feet of the source.

To estimate the acreage of the project area that could be affected by road-generated fugitive dust, a GIS-generated mileage total for all improved exotic and improved natural surface roads within the project area was calculated and then buffered on each side of the road centerline by 578 feet to equal the average total width from the above two mentioned studies (1,156 feet). The two-track road mileage was not included in the calculations because of their minimal use. The results indicate that approximately 260,483 acres could be affected by road-generated fugitive dust deposition, or about 24.3 percent of the project's total land-surface area. This total, at any given time, would be dependent upon season of use, the primary factors listed in this section, and weather-related factors, especially the timing and amount of precipitation events (or lack thereof). A proactive and aggressive road-watering/dust-suppression program could noticeably lower this estimate during the hotter and drier summer months that are generally associated with greater dust-generation potential.

3.6.5 Biological Soil Crusts

Biological soil crusts (BSCs), also referred to as cryptogamic, microbiotic, cryptobiotic, and microphytic crusts, are a complex assemblage of organisms including cyanobacteria, green algae, mosses, lichens, microfungi, and other bacteria that colonize the first few millimeters of the soil surface. Soil crusts are found in all hot, cool, and cold arid and semi-arid regions and may constitute up to 70 percent of the living cover in some plant communities (Belnap 1994). The functions of BSCs in rangeland ecosystems include retention of soil moisture by serving as a living mulch on the soil surface; reduction of wind and water erosion; fixing atmospheric nitrogen; and contributing to soil organic matter (Eldridge and Greene 1994).

The primary environmental factors that influence the distribution of biological soil crusts include elevation, precipitation volume, timing of precipitation, physical and chemical properties of the soil, topography, and disturbance regimes (Belnap 2001). The historic and current distribution of BSCs in the project area is largely unknown. However, field work conducted by HWA during May and June of 2007 found soil crusts at several locations within the project area, with moss crusts the most frequently encountered. Moss crusts were found growing within cacti aggregations or underneath shrub canopies, and less frequently in the open plant interspaces. Moss crusts were also observed in several plant communities including those dominated by Wyoming big sagebrush, mountain big sagebrush, saltbush, and greasewood. Cyanobacterial crusts were observed in portions of the project area where the soils were less stable (e.g., sandy areas) or the crusts were re-establishing after disturbance. Lichen crusts were observed less frequently than moss or cyanobacterial crusts. The Creston grazing exclosure within the project area was observed to have a well-established lichen crust, including: *Aspicilia, Caloplaca, Collema, Xanthoparmelia,* and *Psora*. The most common moss was *Tortula*. Crustal development was greatest underneath shrub canopies or on the edges of bunchgrasses and less so in the plant interspaces. The assemblage of species present at this Wyoming big sagebrush site indicates a late-successional stage of crust development. This provides evidence that mature and diverse soil crusts have the potential to occur within the project area, given suitable environmental conditions.

3.7 INVASIVE, NON-NATIVE PLANT SPECIES

Generally, the term "weed" can be used for any unwanted plant. Terms such as aliens, exotics, and invasives are used interchangeably to describe specific weeds. All these descriptions have a common concept: plants introduced into an area in which they did not evolve that have the potential to cause noticeable economic and/or ecological impacts. When weeds become so widespread that they threaten crops, livestock, or native species, they may become more than just a "weed." They might then be termed "noxious weed," "invasive species," "exotic species," "alien species," or some similar term as set forth in law by each governing body or land-management agency.

Invasive plant species pose a threat to the long-term productivity, diversity, and aesthetic values of lands within the RFO. Recent extended drought conditions in Wyoming, in conjunction with unprecedented energy development and other construction activities in western Wyoming, have favored the establishment and spread of invasive weed species.,This has occurred not only in disturbed habitats, but also in native rangeland where the stress of drought has resulted in decreased vigor, annual production, resilience, and competitive capabilities of native grassland and shrub communities, thus creating an ideal environment for invasion and establishment of aggressive and invasive weedy species.

The principal invasive weeds known to occur in or near, or which have been treated within, the project area include (BLM 2002) Russian knapweed (*Centaurea repens*), houndstongue (*Cynoglossum officinale*), halogeton (*Halogeton glomeratus*), hoary cress (whitetop) (*Cardaria draba* and *Cardaria pubescens*), perennial pepperweed (giant whitetop) (*Lepidium latifolium*), spotted knapweed (*Centaurea maculosa*), common burdock (*Arctium minus*), and saltcedar (*Tamarix* spp.). The primary impact of these invasive species to the range resource is their ability to out-compete native species; in addition to their competitive nature, Russian knapweed, halogeton, and houndstongue are poisonous to wildlife and/or livestock.

Many of these invasive species are associated with disturbed areas such as road/pipeline rights-of-way and well pads. Other common invasive weed species observed in the project area include cheatgrass (*Bromus tectorum*), Russian thistle (*Salsosa kali*), netseed lambsquarter (*Chenopodium berlandieri*), bull thistle (*Cirsium vulgare*), black henbane (*Hyoscyamus niger*), common mullein (*Verbascum thapsus*), clasping pepperweed (*Lepidium perfoliatum*), kochia (*Kochia scoparia*), as well as several wild mustards.

Of the invasive plant species found in the project area, halogeton represents an ecological and economic threat to the area due to its unparalleled rapid infestation and widespread establishment. Prior to the onset of extended drought conditions in Wyoming beginning in 2000, halogeton was present at low densities in southwest and south-central Wyoming but its presence was primarily restricted to range sites degraded over time by heavy livestock concentrations such as near feed-grounds, corrals, and travel-ways or disturbed sites such as the reclaimed Santa Fe Browning gravel pit near Wild Horse Butte (Bennett 2004). Extensive invasive weed surveys conducted by HWA during the 2007 growing season indicated that approximately 13,353 acres, or about 1.2 percent of the surface area of the project area, were infested with halogeton. This is a conservative estimate based upon surveys at specific sites such as well pads and road/pipeline rights-of-way (HWA 2008b).

Although not quantified, the actual surface area infested by halogeton could be greater based on field observations that halogeton spreads laterally from infested road/pipeline rights-of-way into adjoining native rangeland. Observations made during the 2007 growing season, especially along the major north/south-oriented roads (e.g., Wamsutter Road) indicated that the lateral spread of halogeton was usually minimal (± 15–20 feet) on the windward (west) side of the road but could extend as far as 0.25 mile on the leeward side (east) of the road right-of-way. The direction of the prevailing winds during October and November when the plants are in the seed-drop stage is probably the dominant variable that controls dispersal direction. Halogeton seed is extremely light and fluffy and easily transported by even a slight breeze. If the same criteria are used as with fugitive dust impacts (**Section 4.7.3.1**), it is evident that as many as 260,000 total acres of disturbed and native rangeland in the project area may be at risk of infestation with halogeton.

3.8 WILDLIFE

3.8.1 Terrestrial Wildlife

Information concerning current and historical wildlife observations and distribution within and near the CD-C project area were obtained from a variety of sources including BLM, USFWS, Wyoming Game and Fish Department (WGFD), Wyoming Natural Diversity Database (WYNDD), and information compiled from personal communications and unpublished data from BLM, WGFD, and USFWS biologists. The WGFD Wildlife Observation System (WOS) and WYNDD are the primary repositories for wildlife information in the state of Wyoming and contain records of wildlife observations for birds, mammals, herptiles (amphibians and reptiles), fish, and species of special concern. Wildlife information for the project area was supplemented with survey data collected by Hayden-Wing Associates, LLC (HWA) during 2006–2007 as part of the baseline and monitoring data requirements for the EIS.

At least 396 wildlife species occur in and around the project area including: 77 mammal, 273 bird, six amphibian, 10 reptile, and 30 fish species (**Appendix H**). All wildlife species are important members of a functioning ecosystem and wildlife community, but most are common and have wide distributions in the region. Consequently, the relationships of most of these species to the proposed project are not discussed in the same depth as species that are Threatened, Endangered, rare, of special concern, of special economic interest, or otherwise of high interest or unique value.

3.8.1.1 Wildlife Habitat

A wide variety of wildlife habitats and associated species occur in the project area. Wildlife habitats that would be affected by the project include the areas that would be physically disturbed by the construction of gas wells, related roads, pipelines, and production facilities, as well as zones of influence surrounding them. Zones of influence are defined as those areas surrounding or associated with project activities where impacts to a given species or its habitat could occur. The shape and extent of such zones varies with species and circumstances.

The project area is located in the Wyoming Basin Omernik Level III Ecoregion (18) and includes portions of the Rolling Sagebrush Steppe (18a) and Salt Desert Shrub Basins (18e) Level IV Ecoregions (Chapman *et al*. 2004). Topography in the project area is characterized by rolling plains interrupted by hills and strike-dip ridges dissected by alluvial and outwash fans that empty into broad, level basins. Ridges, hills, and rolling plains support vast areas of mixed-grass prairie and Wyoming, mountain, and basin big sagebrush communities. Active and stabilized sand dunes, as well as disjunct playas and alkaline flats, are interspersed throughout the project area where existing conditions are favorable for their formation. Vegetation communities in the poorly drained, alkaline basins are dominated by arid-land shrubs like greasewood, shadscale, and Gardner's saltbush. Riparian and wetland habitats are scarce and found only at a few locations in the project area. Freshwater wetlands in the northern portion of the project area occur along Riner Road (BLM 3203) in the Chain Lakes area, and along Luman Road (i.e., SCR 20) north of Horseshoe Bend where a flowing well supplies year-round water to an enclosed water impoundment surrounded by emergent vegetation. A few large water impoundments along Muddy Creek create a series of connected semi-permanent wetlands in moist years in the southeastern portion of the project area. Detailed descriptions of vegetation community types within the project area are discussed in **Section 3.6 Vegetation**.

3.8.1.2 Big Game

Big game are included in the discussion due to their high interest and economic values. Three big game species occur in the project area, including pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), and elk (*Cervus elaphus*). Big game populations are managed by the WGFD within areas designated as Herd Units. Hunt Areas are the geographic boundaries within which hunting licenses are valid. Herd size and viability of big game populations are dependent on the combination, availability, and quality of seasonal ranges, which overlap among species and fulfill different requirements for resident and migratory big game populations. **Table 3.8-1** shows Herd Unit population sizes and parameters within the project area from WGFD Job Completion Reports. Herd population objectives are set by WGFD each year based on a variety of factors including, but not limited to, the carrying capacity of the habitat, weather (e.g. drought), habitat fragmentation, and competition with other ungulates.

Extreme drought occurred in the Green River Basin from 2000–2004, lessened in 2005, and then returned again in 2006 and 2007. Higher-than-normal snowfall during the winter of 2007–2008 increased winter mortality above normal. The winters of 2008–2009 and 2009–2010 were mild and drier than normal and winter mortalities were few. The springs of 2009 and 2010 saw above-average precipitation and seasonable temperatures resulting in above-average forage production.

Table 3.8-1. Big game Herd Unit population parameters within the CD-C project area

Species	Herd Unit (number)	Herd Unit total acreage	Percent within project area	Acreage within project area	Population Trend 2001-2009	Population Estimate 2009	WGFD Population Objective	Fawn:Doe Ratio 2009
Pronghorn	Baggs (438)	890,200	9.2	81,530	Slight increase	6,849	9,000	61:100
	Bitter Creek (414)	183,6992	23.3	428,104	Slight decrease	8,594	25,000	36:100
	Red Desert (615)	2,167,952	25.9	560,439	Slight decrease	14,355	15,000	60:100
Mule Deer	Baggs (427)	2,142,656	23.8	509,650	Slight increase	19,845	18,700	64:100
	Steamboat (430)	2,567,106	13.4	343,863	Increasing	4,600	4,000	47:100
	Chain Lakes (650)	699,626	30.9	216,560	Increasing	475	500	Not available
Elk	Sierra Madre (425)	363,651	22.7	82,511	Slight increase	8,957	4,200	37:100
	Steamboat (426)	2,533,733	13.6	343,765	Decreasing to meet objective	1,500	1,200	54:100
	Petition (430)	1,838,167	23.3	427,496	Stable	Not available	300	Not available
	Shamrock (643)	699,477	30.9	216,301	Decreasing to meet objective	130	75	Not available

Source: WGFD 2011b

Pronghorn are the most abundant big game within the project area. The project area includes portions of five Hunt Areas (53, 55, 57, 60, and 61) and three Herd Units (**Table 3.8-1**; **Map 3.8-1**). All three Herd

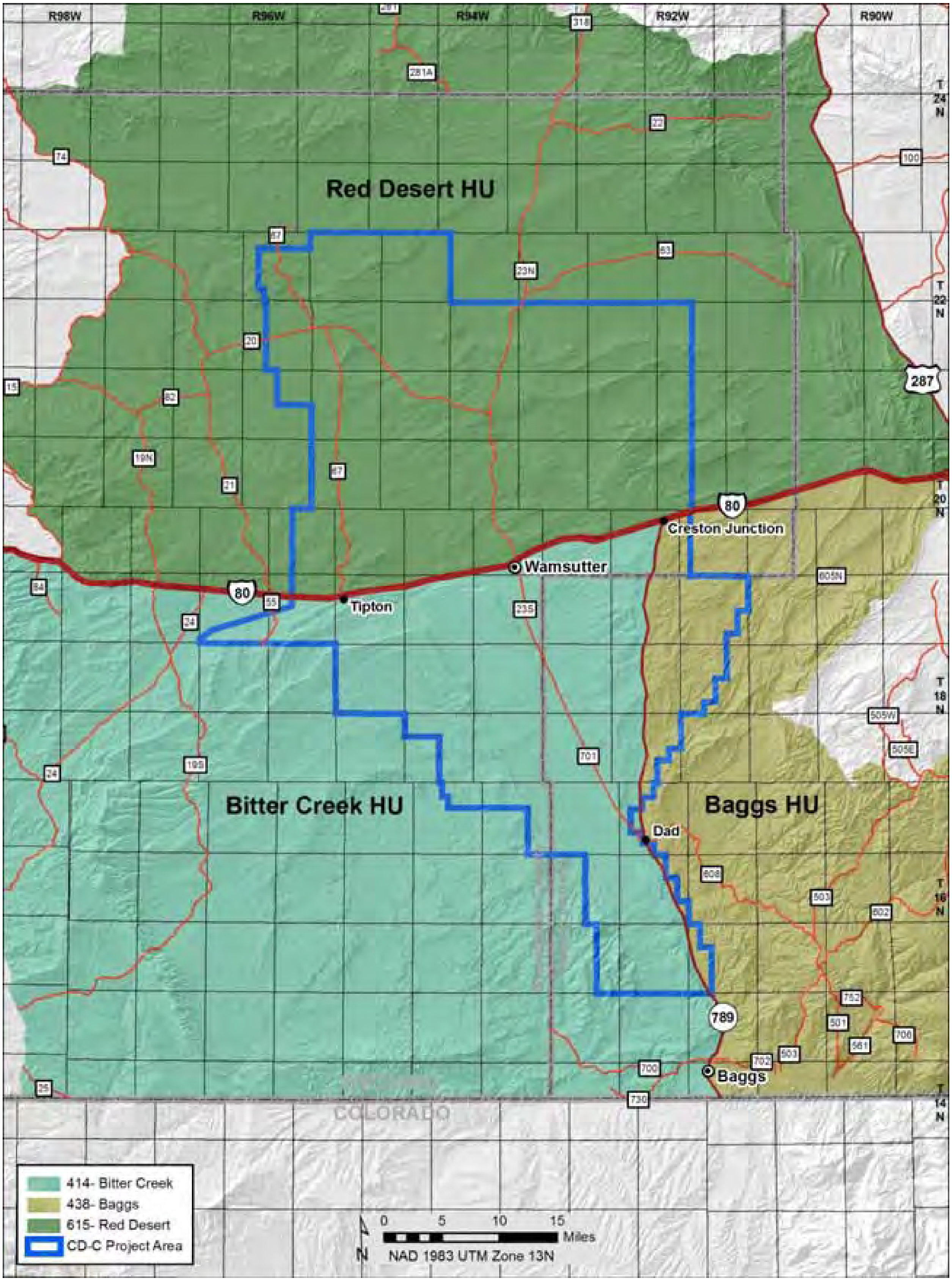
Units are much larger than the portion within the project area, with 26 percent of the Red Desert Herd Unit, 23 percent of the Bitter Creek Herd Unit, and 9 percent of the Baggs Herd Unit acreages contained within the project area. Herd numbers can be affected by several factors including weather events (drought and severe winters), the impacts of excess population numbers (over acceptable management levels) upon habitat, hunting quotas, and disease. Meeting population objectives can depend upon the availability of human resources, the accuracy of wildlife information collected, weather variables, disease, and hunter harvest rates. Average hunter success in the pronghorn Hunt Areas in the CD-C project area is 92 percent, resulting in a prorated annual harvest of approximately 640 animals (WGFD 2009 data). Refer to **Section 3.12 Recreation** for a more detailed discussion. Pronghorn seasonal ranges within the project area include spring/summer/fall (3.3 percent), winter/yearlong (88.3 percent), and crucial winter/yearlong (8.4 percent) (**Table 3.8-2**; **Map 3.8-2**). Although over a dozen pronghorn migratory movements have been documented within the project area, the corridors are broad and poorly defined (Map 3.8-2).

Table 3.8-2. Big game seasonal ranges (acres) within the project area

Species	SEASONAL RANGE[1]							
	CW	CW/Y	W	W/Y	Y	S/S/F	OUT	UND
Pronghorn	--	90,310	--	944,678	--	35,085	--	--
Mule Deer	3,973	13,876	--	491,800	89,039	--	471,385	--
Elk	--	--	26,894	--	64,797	--	550,343	428,039

[1] *Seasonal ranges include: Crucial Winter (CW) and Crucial Winter/Year-long (CW/Y) and describe ranges that have been identified as a determining factor in a population's ability to maintain itself at a specified level (theoretically at or above the population objective) over the long term. Not all habitats within designated crucial winter range are of equal quality. Areas with higher quantity and quality of forage and areas that provide cover from extreme winter weather conditions provide the best-quality crucial winter range habitat. Crucial ranges are typically used 8 out of 10 winters; Winter (W) are used by a substantial number of animals during winter months (December through April; WGFD 2011b); Winter/Year-long (W/Y) ranges are occupied throughout the year but during winter they are used by additional animals that migrate from other seasonal ranges; Year-long (Y) ranges are occupied throughout the year but additional animals do not migrate to this type of seasonal range during winter; Spring/Summer/Fall (S/S/F) ranges are used before and after winter conditions persist; Non-use areas (OUT) contain habitats of limited or no importance to the species; Undetermined use areas (UND) are areas or habitats which are expected to or do support a population or portion of a population of animals, but for which the distribution and importance of the area has not been sufficiently documented to designate a seasonal range.*

Only 16 percent of the CWR for the Red Desert, Bitter Creek, and Baggs Herd Units occurs within the project area. In the springs of 2007, 2008 and 2010, a pronghorn CWR habitat assessment was conducted to attempt to define current conditions and identify factors that may be limiting the pronghorn population within the project area. CWR has long been established, and is accepted, as the most limiting factor for overall pronghorn populations within the state of Wyoming. However, several other factors can affect population trends including severe drought, winter severity, hunter harvest, or the impacts of excess individuals (over acceptable management levels) on habitat. For this assessment, the focus was placed on the identified CWRs within the project area which also serve as yearlong habitat for pronghorn. Therefore, an assessment was performed to determine the relative condition of the CWRs as both winter and yearlong range. In coordination with the WGFD, seven locations were identified to conduct the condition-class studies. Standard 100-foot line-intercept transects were used to gather vegetation quality and quantity data. The Extensive Browse method was used to gather utilization, age-class, and form-class information, and density board measurements were used to gather vertical cover and vegetation height estimates. The above data were then analyzed by two separate methods. The first method employed a Habitat Suitability Index model developed in Wyoming specifically for analysis of pronghorn winter ranges (Allen et al. 1984). The second is a BLM-accepted method for analysis of yearlong pronghorn range (BLM 1980). The results from these utilization analyses establish a baseline for future year-to-year comparisons and trends at these sample points (**Table 3.8-3**).



Map 3.8-1. Pronghorn Herd Units in and around the CD-C project area

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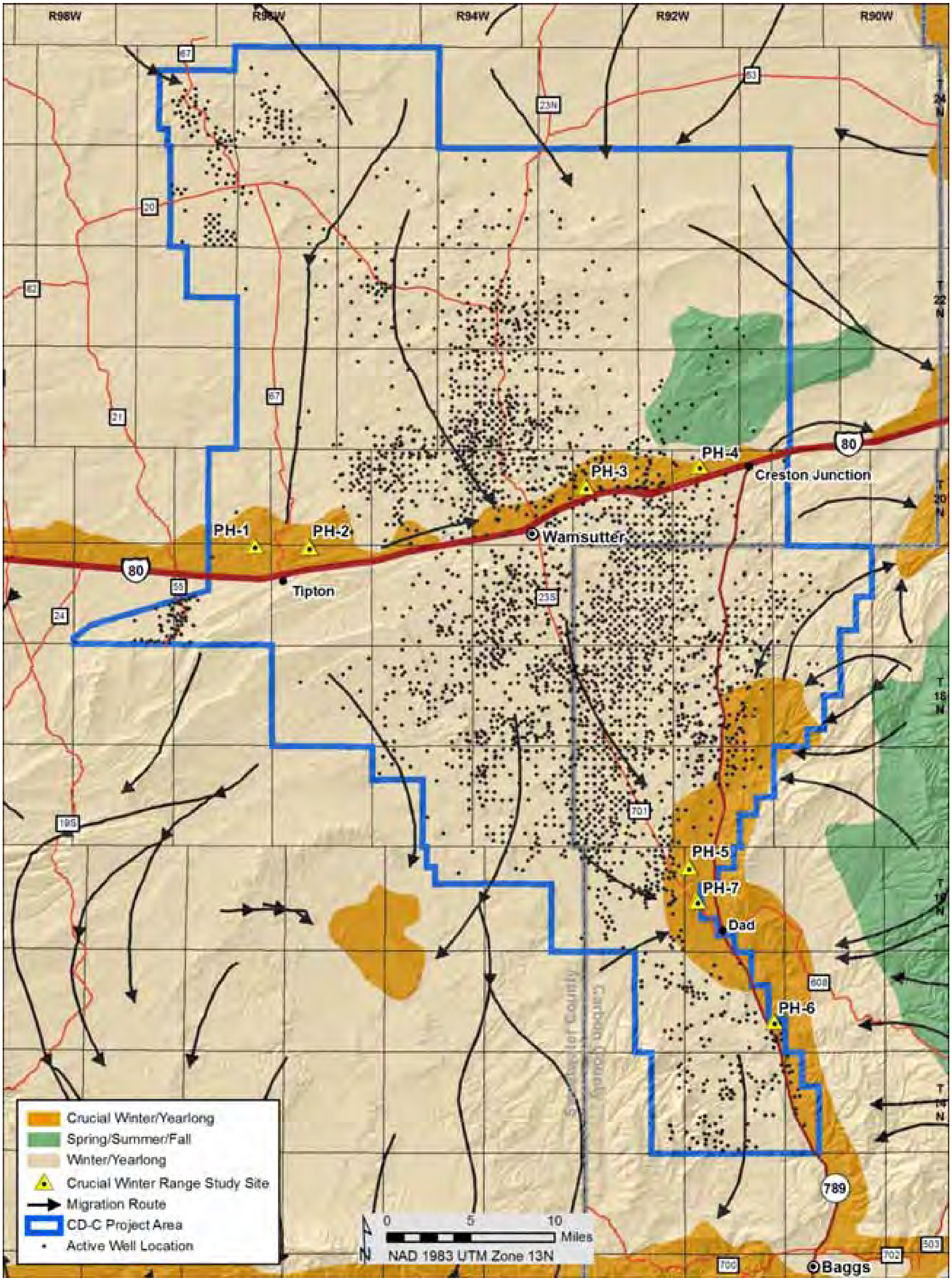

Map 3.8-2. Pronghorn seasonal ranges and migratory movements in and around the CD-C project area

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Table 3.8-3. Pronghorn Crucial Winter Range condition assessment results, 2007, 2008, and 2010

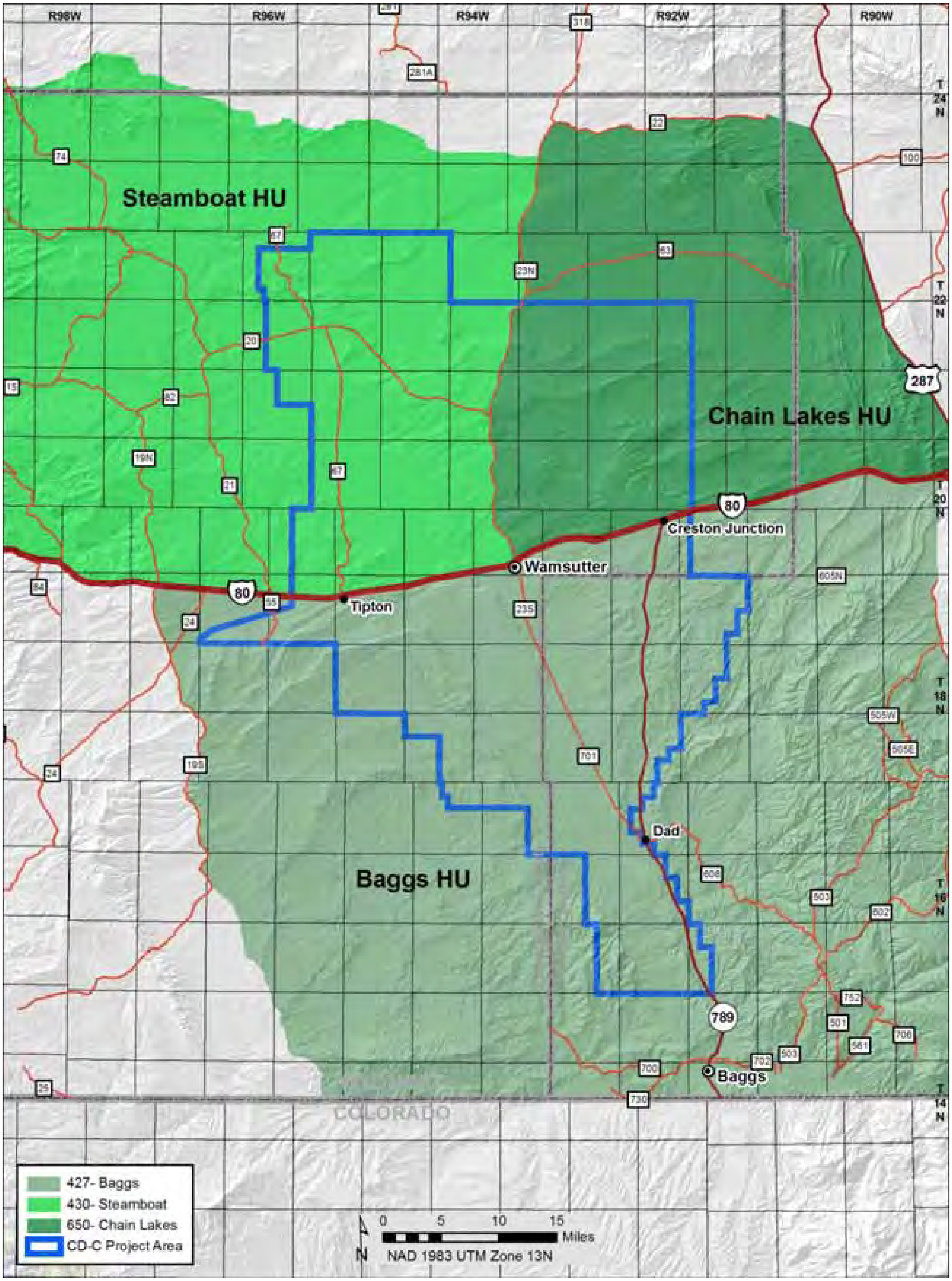
Study site (Map 3.8-2)	Year	Crucial Winter Range Rating[1]	Crucial Winter Range Score [1,]
PH-1	2007 2008 2010	Fair Fair Fair	45 33 33
PH-2	2007 2008 2010	Fair Fair NA	32 26 0
PH-3	2007 2008 2010	Fair Fair Poor	30 26 20
PH-4	2007 2008 2010	Fair Fair Fair	43 45 43
PH-5	2007 2008 2010	Fair Fair Fair	30 33 43
PH-6	2007 2008 2010	Poor Poor Fair	24 24 31
PH-7	2007 2008 2010	Poor Fair Fair	19 26 28

[1] *CWR score is the calculated WFCI (Winter food/cover index)Wyoming pronghorn winter range habitat suitability index, Allen et al. (1984).*
[2] *Fair, poor, and good are all relative ratings as defined by the BLM based on the numerical outcome of the condition assessment.*

Generally, current conditions of pronghorn CWR are rated as "fair," reflecting the moderate use of mature stands of Wyoming and mountain big sagebrush. In addition, CWRs north of I-80 are experiencing slightly less use than the CWRs along WY 789.

Mule Deer are common year-round residents within the project area. The project area supports resident and migratory mule deer populations, and includes portions of five Hunt Areas (82, 84, 98, 100, and 131) and three Herd Units (**Table 3.8-1, Map 3.8-3**). Average hunter success in the five mule deer Hunt Areas in the CD-C project area is 45 percent, resulting in a prorated annual harvest of approximately 2,100 animals (WGFD 2009 data). Refer to **Section 3.12 Recreation** for a more detailed discussion. At least a dozen mule deer migratory movements have been documented in the southern portion of the project area (**Map 3.8-4**). In addition, a telemetry study has revealed migratory movements through the southeastern portion of the project area (Sawyer 2007).

Assessments conducted in 2001 determined that mule deer CWR located along and near the far southeastern edge of the project area was not meeting Standard #4 – Wildlife Habitat Health (BLM 2002; **Map 3.8-4**). Juniper and sagebrush dominance, declining shrub communities, over-browsing of favored shrub species, and low forb composition were some of the habitat concerns cited (BLM 2002). Although this site may not be meeting the standard, broader areas within the landscape may be ecologically functional. Changes in management may be necessary to address making progress toward meeting this standard in the future.



Map 3.8-3. Mule Deer Herd Units in and around the CD-C project area

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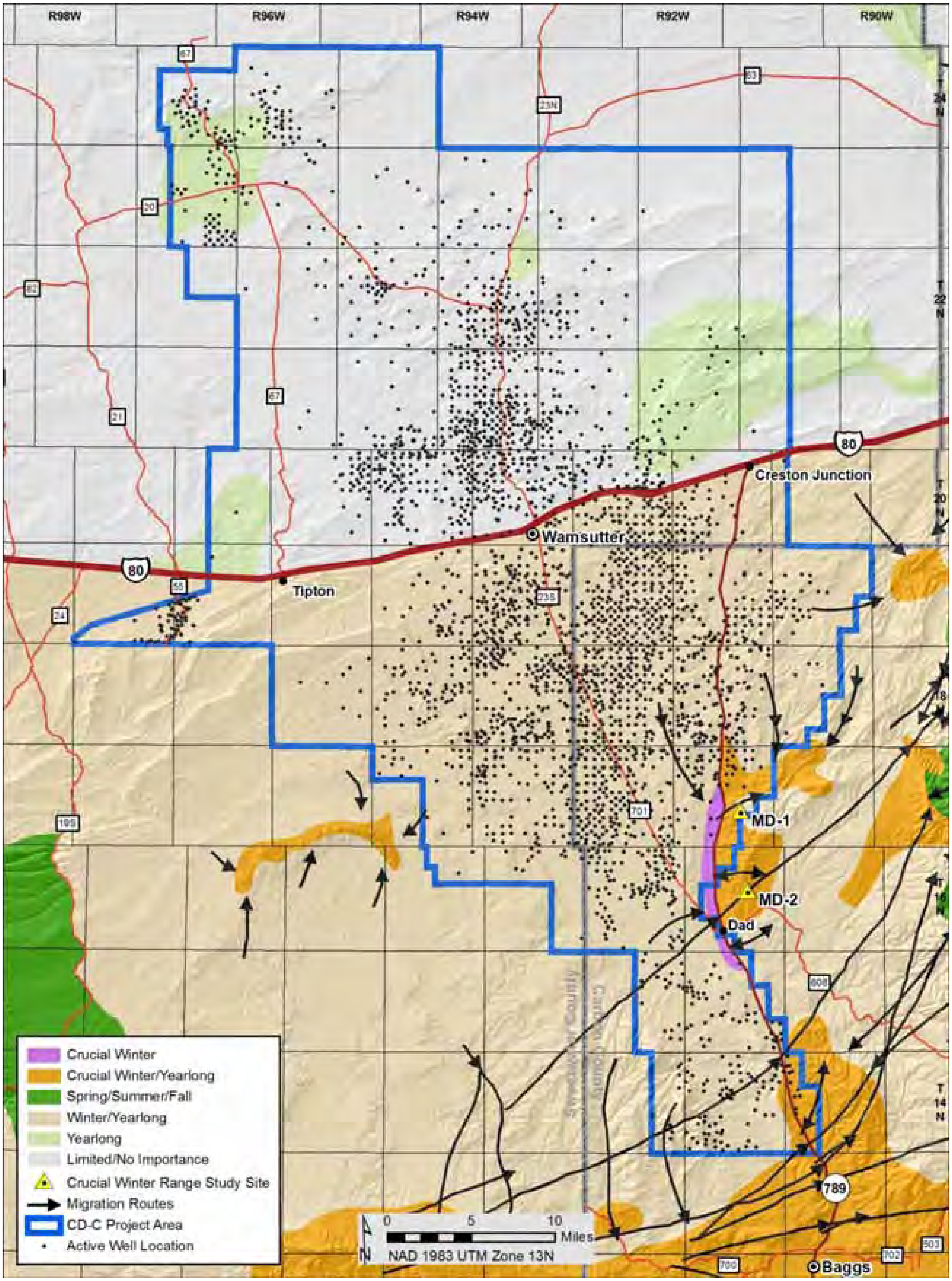


Map 3.8-4. Mule deer seasonal ranges and migratory movements in and around the CD-C project area

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

Only 6.3 percent of CWR acreage for the Baggs Herd Unit occurs within the project area. Mule deer CWR habitat assessments were conducted concurrent with pronghorn CWR habitat assessments conducted in 2007, 2008, and 2010. As with pronghorn, mule deer CWR is the most limiting factor for populations within the state of Wyoming. In coordination with the WGFD, two locations were identified to conduct the condition-class studies. The Extensive Browse and density board methods were also employed to collect data on mule deer CWR sites. The data were then analyzed according to BLM-accepted methods for analysis of mule deer winter range (BLM 1979). The results from these utilization analyses establish a baseline for future year-to-year comparisons and trends at these sample points (**Table 3.8-4**).

Table 3.8-4. Mule deer Crucial Winter Range condition assessment results, 2007, 2008, and 2010

Study site (Map 3.8-4)	Year	Crucial Winter Range Rating[1]	Crucial Winter Range Score[1, 2]
MD-1	2007 2008 2010	Fair Poor Fair	54.39 42.63 54.39
MD-2	2007 2008 2010	Good Good Good	64.68 61.74 63.21

[1] *Fair, poor, and good are all relative ratings as defined by the BLM based on the numerical outcome of the condition assessment.*

[2] *Mule deer CWR score and rating calculated by BLM (2008).*

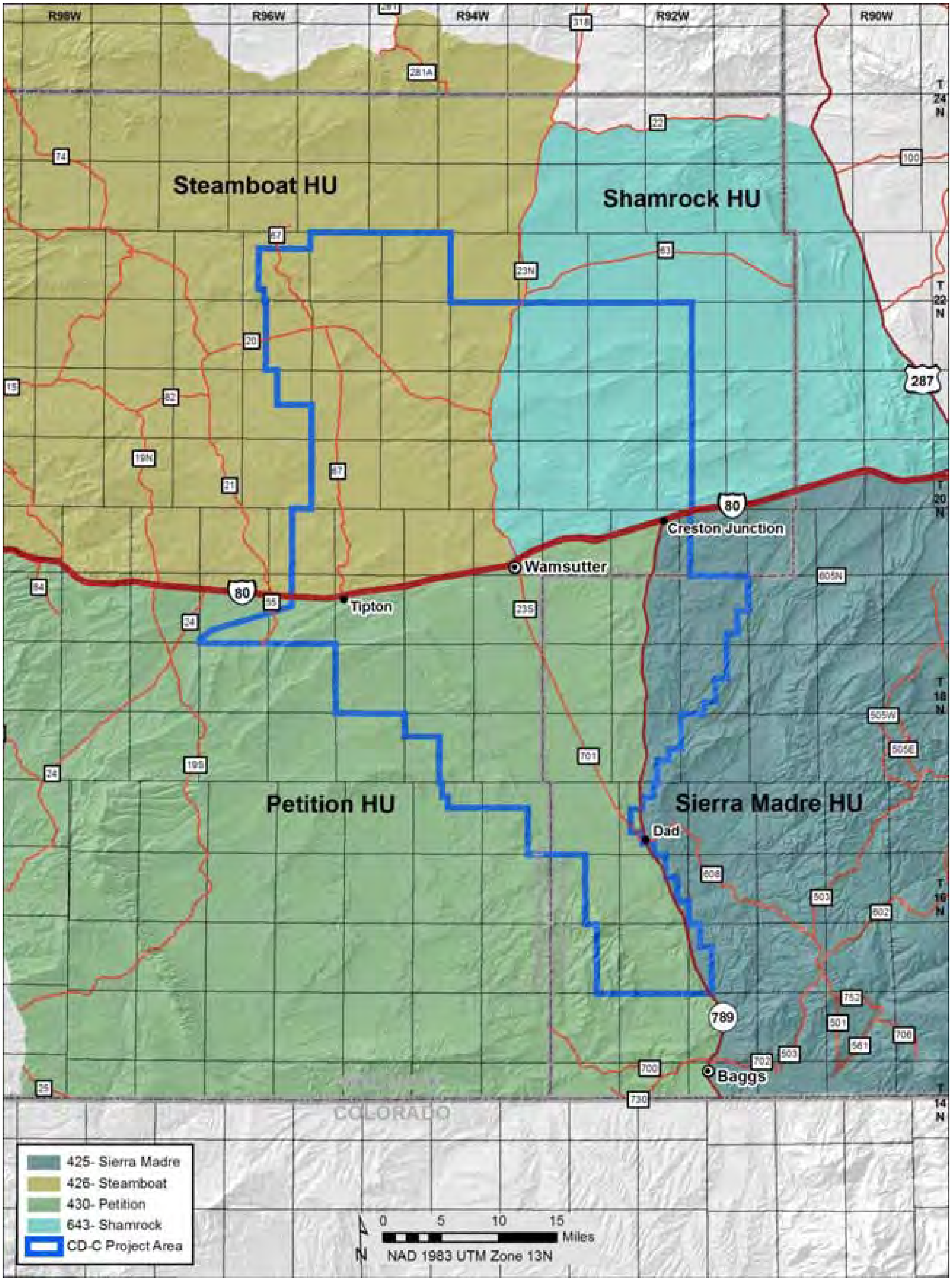
Data are available for only two sites and may indicate that variable forage conditions likely exist across the analysis area. Current forage conditions in mule deer CWR associated with the project area were similar to those of pronghorn; however, heavier use was evident at mule deer sites. At least a dozen mule deer migratory movements have been documented in the southern portion of the project area (**Map 3.8-4**). In addition, a telemetry study has revealed migratory movements through the southeastern portion of the project area (Sawyer 2007). As discussed above, animal movement along known migratory routes in the southeastern portion of the project area are compromised by WY 789, energy development, and numerous rangeland and highway fences (Feeney et al. 2004, WGFD 2010). Mule deer use of the underpasses constructed under WY 789 has been well documented using remote cameras (WYDOT 2012). The range condition data provided in Table 3.8-4 is indicative of the forage condition within migration routes. Although current conditions of mule deer CWR associated with the project area were similar to those of pronghorn, heavier use was evident at mule deer sites. Nevertheless, results indicated that mule deer CWR sites have mature stands of big sagebrush with adequate canopy cover and overall production.

Elk are locally common in certain areas within the project area. The project area includes portions of five Hunt Areas (21, 100, 108, 118, and 124) and four Herd Units (**Table 3.8-1, Map 3.8-5**). Average hunter success in the five elk hunt areas in the CD-C project area is 47 percent, resulting in a prorated annual harvest of approximately 1,440 animals (WGFD 2009 data). Refer to **Section 3.12 Recreation** for a more detailed discussion. Elk seasonal ranges located within the project area include yearlong (6.1 percent), winter (2.5 percent), non-use (51.4 percent), and undetermined use areas (40.0 percent; **Table 3.8-2, Map 3.8-6**). No elk CWR has been designated or elk migration routes documented within the project area (Map 3.8-6). Therefore no elk CWR site-sampling was conducted. Although no elk migration routes have been mapped in the project area, they may be present. Elk do migrate from the Sierra Madre mountain range to winter range along the Atlantic and Red Rims east of the project area (Map 3.8-6), and elk have been documented using the Baggs/WY 789 underpasses (WYDOT 2012)

Big Game Summary

The project area is used by pronghorn, mule deer, and elk, although the areas and season of use vary by species. CWR (i.e., crucial winter and crucial winter/yearlong ranges) of pronghorn and mule deer collectively comprise approximately 92,842 acres (8.7 percent) of the project area (**Map 3.8-7**). The Rawlins RMP (BLM 2008a) states that habitat quality will be functionally maintained within areas of overlapping big game CWR. Overlapping pronghorn and mule deer CWRs comprise 15,314 acres (1.4 percent) of the project area (Map 3.8-7).

The project area also hosts wild horses, which over time may result in direct (competitive displacement) and indirect (resource-sharing) competition with pronghorn, mule deer, and elk (see **Section 3.10 Wild Horses**). Wild horse populations may impact ungulate habitat over an extended period of time.



Map 3.8-5. Elk Herd Units in and around the CD-C project area

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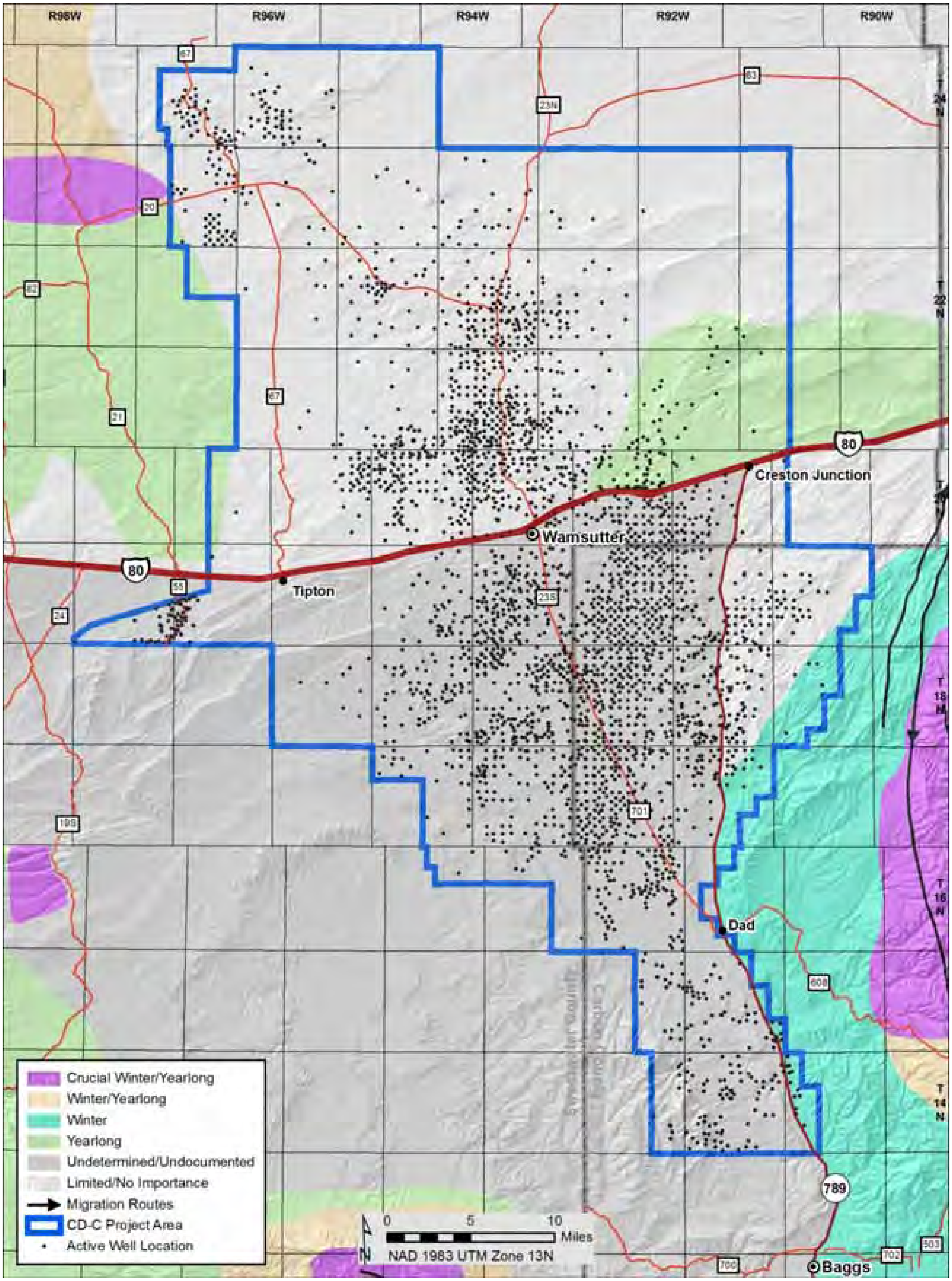

Map 3.8-6. Elk seasonal ranges and migratory movements in and around the CD-C project area

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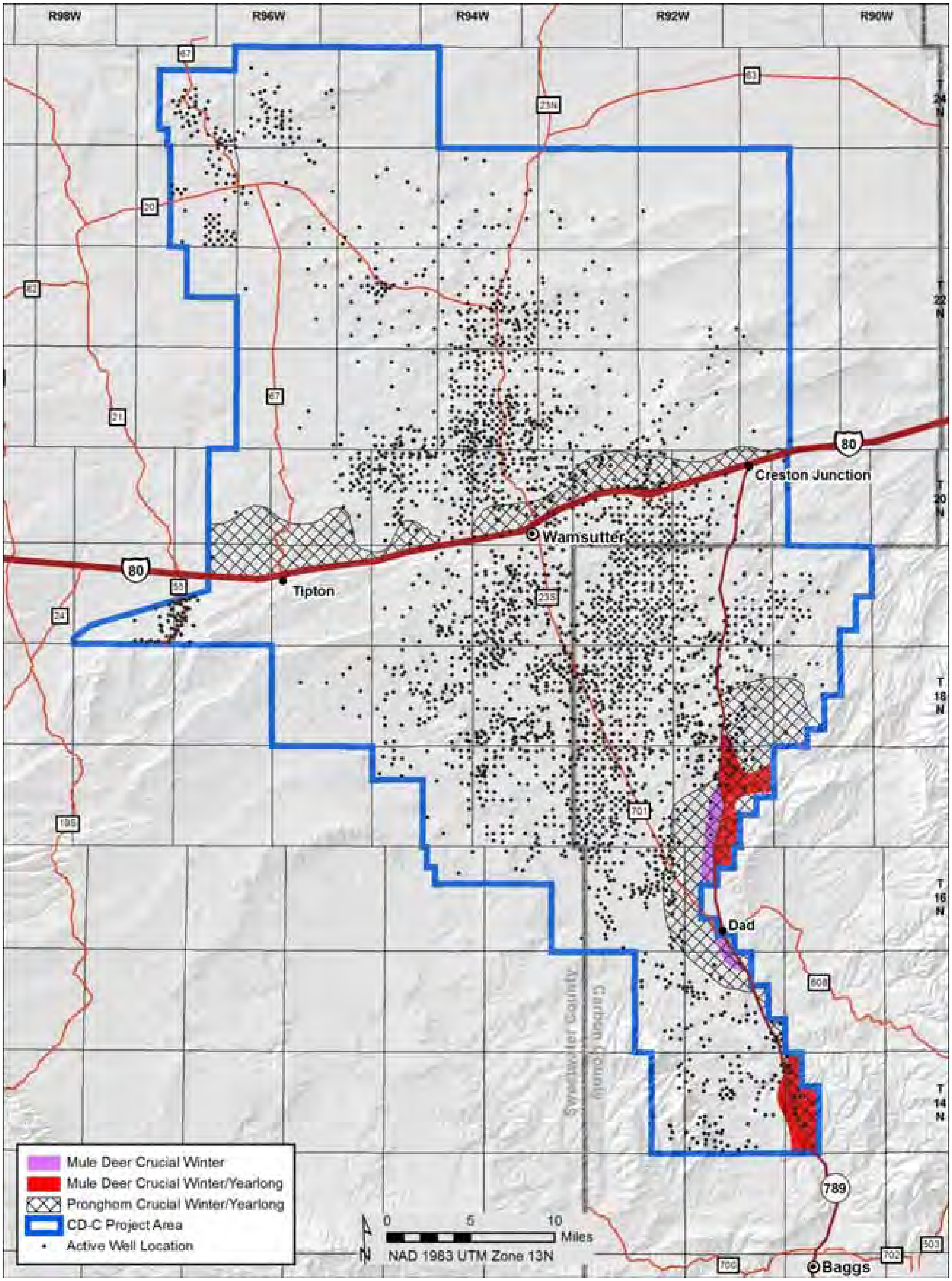


Map 3.8-7. Big game Crucial Winter Ranges in the CD-C project area

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

3.8.1.3 Upland Game Birds

Greater sage-grouse (*Centrocercus urophasianus*), Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*), and mourning doves (*Zenaida macroura*) occur within the project area (WGFD 2004a). Suitable habitat for chukar (*Alectoris chukar*), gray partridge (*Perdix perdix*), ring-necked pheasant (*Phasianus colchicus*), blue grouse (*Dendragapus obscurus*), ruffed grouse (*Bonasa umbellus*), and wild turkey (*Meleagris gallopavo*) does not exist within the project area, although these species are present in surrounding areas (WGFD 2004a). Upland game birds are managed by the WGFD within upland game management areas. The project area includes parts of three Upland Game Management Areas (UGMAs): Red Desert UGMA 9; Bitter Creek UGMA 10; and Sierra Madre UGMA 25. Greater sage-grouse is a Candidate species for listing under the ESA and Columbian sharp-tailed grouse is designated as a sensitive species by the BLM. These species are discussed in **Section 3.9 Special Status Species**.

Mourning doves occupy a wide variety of habitats. Within the project area, mourning doves occur in sagebrush-grassland, mountain shrub, and riparian vegetation communities. Mourning doves breed within and migrate through the project area (WGFD 2004a). Based on recent records, mourning doves harvested within the project area account for a very small percentage of the state total (WGFD 2005b).

3.8.1.4 Raptors

Twenty-six raptor species are known to occur in or around the project area, including 14 that breed or potentially breed, two that over-winter, and ten that have been recorded as transients or migrants (**Table 3.8-5**). Five species are designated as sensitive by the BLM and are discussed in detail in **Section 3.9 Special Status Species**.

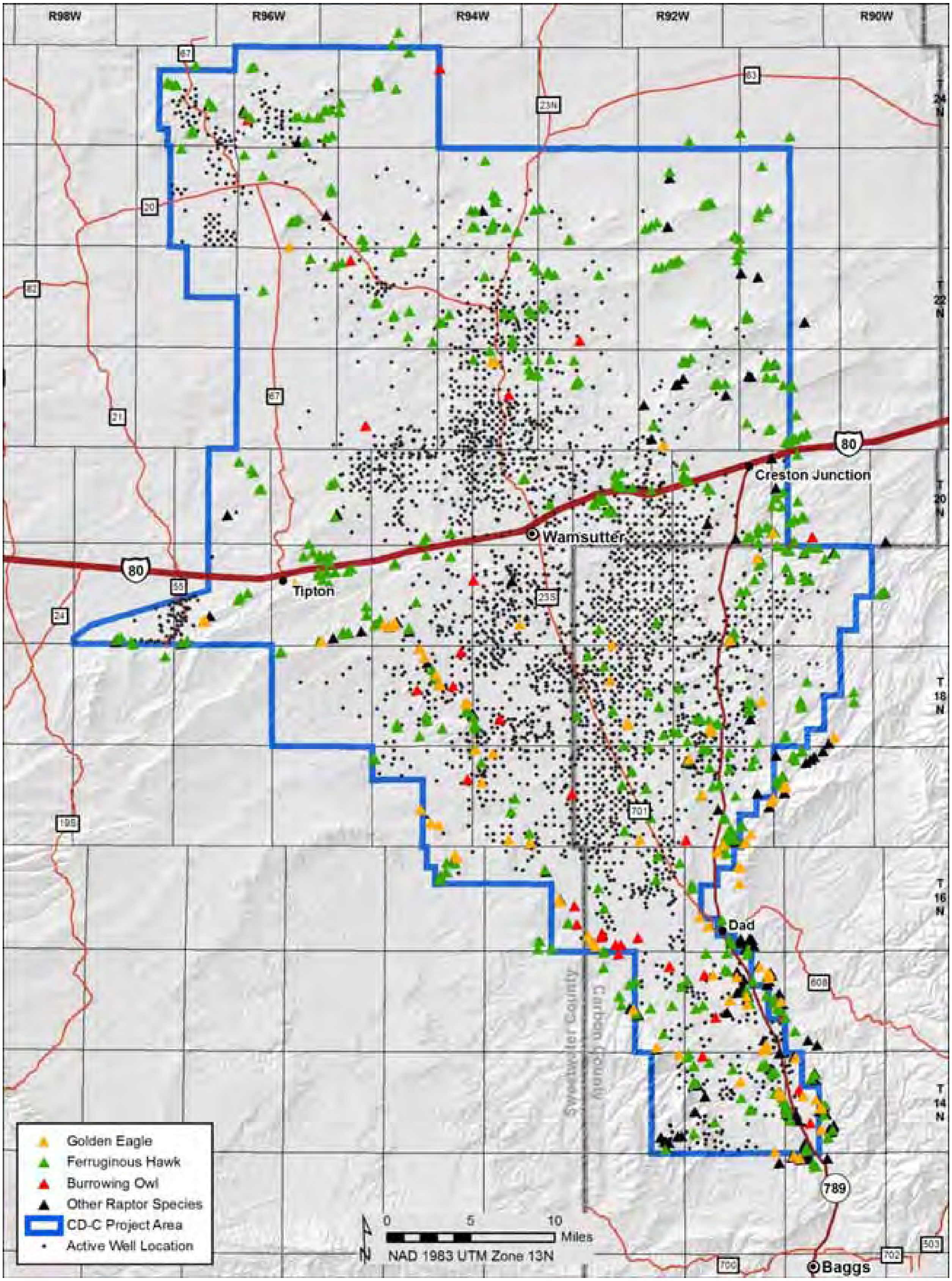
A variety of raptor breeding, hunting, and winter habitats occur within the project area. Grasslands, shrublands, trees and shrubs in riparian areas, and cliffs, low bluffs, rocky outcrops, and badland breaks all provide suitable nest substrates throughout the project area. Muddy Creek and drainages that support trees and other riparian vegetation provide habitat for tree-nesting species and provide potential roosting sites for wintering raptors. Agency and contract wildlife biologists have located at least 938 raptor nests belonging to at least 11 species in or within one mile of the project area (BLM 2007a; **Table 3.8-5**; **Map 3.8-8**). The raptor species utilizing 79 of these nest sites are unknown.

Table 3.8-5. Occurrence potential and documented nest sites of raptor and vulture species within the CD-C project area

Common Name[1]	Scientific Name	Occurrence Potential[2]	Documented Nest Sites
American kestrel	*Falco sparverius*	B	18
Bald eagle*	*Haliaeetus leucocephalus*	t	--
Barn owl	*Tyto alba*	t	--
Broad-winged hawk	*Buteo platypterus*	t	--
Burrowing owl*	*Athene cunicularia*	B	31
Cooper's hawk	*Accipiter cooperii*	B	4
Ferruginous hawk*	*Buteo regalis*	B	577
Golden eagle	*Aquila chrysaetos*	B	108
Great horned owl	*Bubo virginianus*	B	15
Gyrfalcon	*Falco rusticolus*	t	--
Long-eared owl	*Asio otus*	B	1
Merlin	*Falco columbarius*	W	--
Northern goshawk*	*Accipiter gentilis*	t	--
Northern harrier	*Circus cyaneus*	B	9
Northern pygmy owl	*Glaucidium gnoma*	t	--
Northern saw-whet owl	*Aegolius acadicus*	t	--
Osprey	*Pandion haliaetus*	t	--
Peregrine falcon*	*Falco peregrinus*	t	--
Prairie falcon	*Falco mexicanus*	B	34
Red-tailed hawk	*Buteo jamaicensis*	B	48
Rough-legged hawk	*Buteo lagopus*	W	--
Sharp-shinned hawk	*Accipiter striatus*	pB	--
Short-eared owl	*Asio flammeus*	pB	--
Snowy owl	*Bubo scandiacus*	t	--
Swainson's hawk	*Buteo swainsoni*	B	14
Turkey vulture	*Cathartes aura*	pB	--

[1] *Special-status species indicated by asterisk*
[2] *Occurrence potential of raptor species includes: known breeding (B); known to be present during breeding season and potentially breed (pB); known to over-winter (W); and known transient or migrant (t)*

It is possible that some of the older documented raptor nests may have deteriorated beyond being suitable for raptor nesting and the nest sites are no longer available or used by breeding raptors. Nevertheless, nest sites with nests in suitable condition have the potential to be active in any given year. Moreover, each year new nests are built. All raptors and their nests are protected from take or disturbance under the Migratory Bird Treaty Act (16 USC, §703 *et seq.*) and Wyoming [Revised] Statute (WRS 23-1-101 and 23-3-108). Golden and bald eagles also are afforded additional protection under the Bald and Golden Eagle Protection Act, amended in 1973 (16 USC, §669 *et seq.*).



Map 3.8-8. Raptor nest site locations in or within one mile of the CD-C project area

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

3.8.1.5 Neotropical Songbirds

Many species of neotropical songbirds utilize the project area for breeding, feeding, migration, and as year-round habitats (**Appendix H, Occurrence Potential of Wildlife in the CD-C Project Area**). All habitats throughout the project area are used to some degree by these species, but especially sagebrush-grassland, mountain shrub, and riparian vegetation communities. The Migratory Bird Treaty Act (16 USC, §703 *et seq.*) protects 836 migratory bird species (to date) and their eggs, feathers, and nests from disturbances. Several migratory raptors and songbird species are also listed as BLM Sensitive Species (**Section 3.9.2**).

3.8.2 Fish

Almost all of the CD-C project area drains into two basins: the Little Snake River Basin (a component of the Colorado River system) and the Great Divide Basin. A very small proportion of the far western part of the project area drains into Bitter Creek, also a component of the Colorado River system. The Little Snake River Basin is fed by Muddy Creek, which drains the southeastern portion of the project area. The majority of the northern part of the project lies within the Great Divide Basin. The Great Divide Basin is closed, with no eventual outflow to an ocean (**Map 3.4-1**).

3.8.2.1 Fish Habitat

Due to limited precipitation, the majority of drainages within the project area are ephemeral. Ephemeral water tables are always below the stream channel, only flowing in direct response to precipitation or snow-melt. Ephemeral waters only support very limited aquatic communities for short periods when surface flow is present, although some ephemeral streams in the project area may be used for spawning. The largest stream within the project area is Muddy Creek, a high-elevation, cold desert stream that is designated as class 2AB by the WDEQ, and supports game and non-game species. Muddy Creek exhibits perennial flow for the majority of its length, and in some years flows intermittently as a result of irrigation water removal south of the George Dew/Red Wash wetlands complex. In years with high runoff amounts, Muddy Creek flows perennially throughout its length. Streamflow varies with location along the drainage.

About 286 reservoirs and ponds (<1–960 acres) are present within the project area (**Section 3.4.2.1**). Some of the ponds and reservoirs that currently exist within the project area are fed by waters recovered from wells drilled at upstream locations, while others are impoundments on small drainages. These man-made impoundments are generally designed to supply water for livestock and wildlife use. Only one of these, Little Robbers Gulch Reservoir, is stocked annually with Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) by the WGFD. None of the others are known to sustain fisheries.

3.8.2.2 General Fish

About 30 species of fish may occur in the project area or in streams upstream or downstream of the project area (**Table 3.8-6**), including ten game-fish species and 20 non-game fish species. This information is based upon species potentially found in the Great Divide and Little Snake River Basins, plus four Threatened and Endangered species present downstream in the Colorado River System. About 14 of the 30 species, including six native species, are likely to be present within the project area. Four of the 30 species are Threatened or Endangered (**Section 3.9.1.3**) and four are BLM Sensitive Species (**Section 3.9.2.3**).

No fish have been collected from any streams within the Great Divide Basin. Consequently, all of the fish present within streams in the project area are found within the Muddy Creek watershed. Some impoundments in the Great Divide Basin portion of the project have been stocked with fish in the past, but none are known to sustain fisheries at the present.

Table 3.8-6. Fish species observed within, or that may potentially occur immediately upstream or downstream of, the CD-C project area

Common Name	Scientific Name	Game or Non-game	Basin[1]	Present in project area	Native	WYNDD	FOW	BLM	MCBMP	WSAM	WGFD	Beatty 2005
Black bullhead	*Ameiurus melas*	Non-game	LSR									x
Bluehead sucker	*Catostomus discobolus*	Non-game	LSR	Yes	Yes	X	X	X	X	X		
Bonytail	*Gila elegans*	Non-game	CR		Yes							
Brook trout	*Salvelinus fontinalis*	Game	LSR, GDB	Yes			X	X	X	X		
Brown trout	*Salmo trutta*	Game	LSR				X					
Channel catfish	*Ictalurus punctatus*	Game	LSR				X					
Colorado pikeminnow	*Ptychocheilus lucius*	Non-game	LSR, CR		Yes		X	X				
Colorado River cutthroat trout	*Oncorhynchus clarki pleuriticus*	Game	LSR			X	X	X	X	X		
Common carp	*Cyprinus carpio*	Game	LSR, GDB				X	X				
Creek chub	*Semotitus atromaculatus*	Non-game	LSR	Yes			X	X	X	X		X
Fathead Minnow	*Pimephales promelas*	Non-game	LSR	Yes				X				X
Flannelmouth sucker	*Catostomus latipinnis*	Non-game	LSR	Yes	Yes	X	X	X	X	X		
Humpback chub	*Gila cypha*	Non-game	CR		Yes							
Iowa darter	*Etheostoma exile*	Non-game	LSR				X	X	X	X		
Longnose dace	*Rhinichthys cataractae*	Non-game	LSR	Yes			X		X	X		
Longnose sucker	*Catostomus catostomus*	Non-game	LSR				X					
Mottled sculpin	*Cottus bairdi*	Non-game	LSR	Yes	Yes		X	X	X	X		
Mountain sucker	*Catostomus platyrhynchus*	Non-game	LSR	Yes	Yes		X	X	X	X		
Mountain whitefish	*Prosopium williamsoni*	Game	LSR		Yes		X		X	X		
Northern Pike	*Esox lucius*	Game	LSR								X	
Rainbow trout	*Oncorhynchus mykiss*	Game	LSR, GDB	Yes			X		X	X		
Razorback sucker	*Xyrauchen texanus*	Non-game	CR		Yes							
Red Shiner	*Cyprinella lutrensis*	Non-game	LSR									X
Redside shiner	*Richardsonius balteatus*	Non-game	LSR	Yes			X	X	X	X		X
Roundtail chub	*Gila robusta*	Non-game	LSR	Yes	Yes	X	X	X	X	X		
Sand Shiner	*Notropis stramineus*	Non-game	LSR	Yes								X
Speckled dace	*Rhinichthys osculus*	Non-game	LSR	Yes	Yes		X	X	X	X		
Walleye	*Stizostedion vitreum*	Game	LSR							X	X	
White sucker	*Catostomus commersoni*	Non-game	LSR	Yes			X	X				X

[1] Basins LSR = Little Snake River Basin
GDB = Great Divide Basin
CR = These species are downstream residents of the Colorado River system.

Data Sources:
- Wyoming Natural Diversity Database (WNDD 2003)
- Fishes of Wyoming (FOW) (Baxter and Stone 1995)
- Muddy Creek Basin Management Plan (MCBMP)(WGFD 1998)
- M. Fowden, pers.comm. 2004
- Bureau of Land Management (BLM) (BLM 2001)
- Warmwater Stream Assessment Manual (WSAM) (WGFD 2004)
- BLM 2001
- Beatty 2005

3.9 SPECIAL STATUS SPECIES

Special-status species include: (1) Threatened, Endangered, Proposed, Candidate, or those petitioned for listing as Threatened or Endangered by the USFWS under the Endangered Species Act (ESA) of 1973, as amended; and (2) those designated by the BLM State Director as sensitive (BLM 2010).

3.9.1 Threatened, Endangered, Proposed, or Candidate Species of Wildlife, Fish, and Plants

Seven species listed by the USFWS as Threatened, Endangered, Proposed, or Candidate pursuant to the ESA, that may be found in the RFO are or potentially are present within the project area (USFWS 2010, **Table 3.9-1**). Four fish species are found downstream of the RFO in the Colorado River system and may be impacted if water depletions occur, or if environmental contaminants are increased within the system. The other four species—Canada lynx, yellow-billed cuckoo, Wyoming toad, and the blowout penstemon—are located within the RFO; however, they are not located nor do they have habitat within or near the CD-C project area.

Table 3.9-1. Occurrence potential of Threatened, Endangered, Proposed, and Candidate species within or near the CD-C project area

Species[1]	Scientific Name	Occurrence Potential within the project area[2]	Status[3]
Mammals			
Black-footed ferret	*Mustela nigripes*	U	Endangered
Birds			
Greater sage-grouse	*Centrocercus urophasianus*	P	Candidate
Amphibians			
Fish			
Bonytail*	*Gila elegans*	PAD	Endangered
Colorado pikeminnow*	*Ptychocheilus lucius*	PAD	Endangered
Humpback chub*	*Gila cypha*	PAD	Endangered
Razorback sucker*	*Xyrauchen texanus*	PAD	Endangered
Plants			
Ute ladies'-tresses	*Spiranthes diluvialis*	pp	Threatened

[1] Presence in the Colorado River system downstream of the project area is indicated by asterisk.
[2] Occurrence potential includes: present (P); potentially present (pp); unlikely (U); very unlikely (VU); and potentially affected downstream (PAD).
[3] Candidate species are those for which the USFWS has sufficient information to propose for listing as threatened or endangered under the ESA, but for which development of a proposed listing regulation is precluded by other higher priority listing actions. Proposed species are those Candidate species that were found to warrant listing as either threatened or endangered and are currently undergoing a 12-month status review. Conservation measures for candidate and proposed species are voluntary but recommended because, by definition, the species may warrant future protection under the ESA if adequate conservation measures are not in place.

3.9.1.1 Threatened or Endangered Wildlife Species

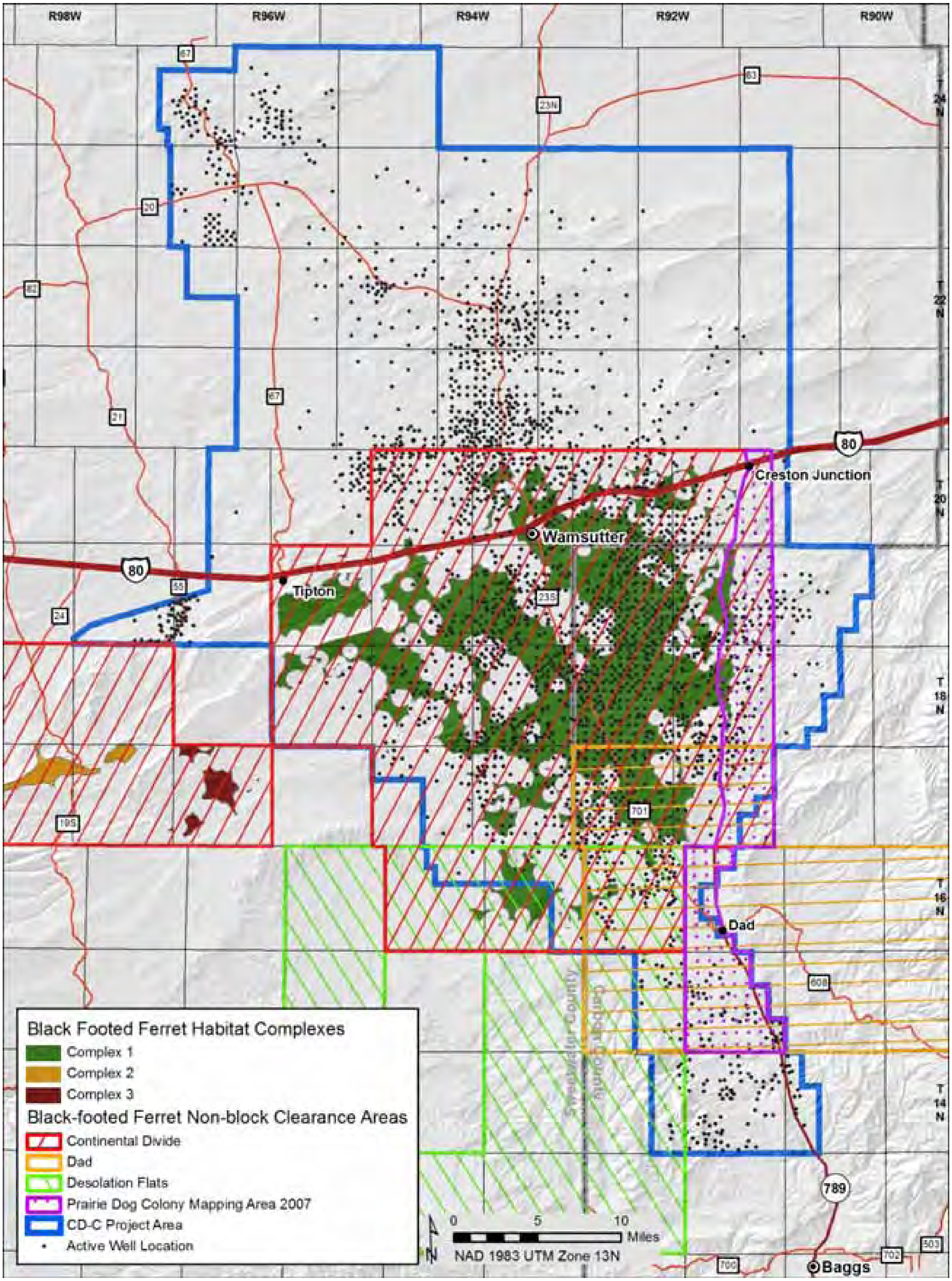
Black-footed ferret. This species is considered the most endangered mammal in the United States. The original distribution of the black-footed ferret in North America closely corresponded to that of the prairie dog (*Cynomys* spp.; Hall and Kelson 1959, Fagerstone 1987). Black-footed ferrets depend almost exclusively on prairie dogs for food and also use prairie-dog burrows for shelter, parturition, and raising young (Hillman and Clark 1980, Fagerstone 1987). The species historically ranged throughout most of the sagebrush and grasslands habitats in Wyoming. Today, the only known population of black-footed ferrets in Wyoming is the result of the reintroduction of captive-bred ferrets in the Shirley Basin (approximately 65 miles northeast of the project area). Reintroductions occurred in Wyoming on federal and state lands from 1991 to 1995. The reintroduced population is classified as nonessential experimental, and currently is self-sustaining.

The USFWS has designated some areas of Wyoming as not likely to have black-footed ferret habitat present; these areas have been “Block Cleared” and do not require ferret surveys prior to activities being permitted. “Non-Block Cleared areas” may contain suitable black-footed ferret habitat. Forty-five percent of the project area is within portions of the Continental Divide, Desolation Flats, and Dad Non-Block Clearance areas, which were not included under the black-footed ferret block clearance letter (**Map 3.9-1**; USFWS 2004b). Prairie-dog colonies occurring within the Continental Divide, Desolation Flats, and Dad non-block clearance areas meet requirements for consideration as black-footed ferret habitat (Biggins *et al.* 1989), and black-footed ferret surveys may be necessary prior to ground-disturbing activities (Biggins *et al.* 1989, USFWS 1989). Mapping and ground surveys indicate that the area and density of active prairie-dog colonies within the project area may be sufficient to support black-footed ferrets. The RFO, in coordination with the USFWS, has refined and mapped the white-tailed prairie dog complex areas that would require pre-disturbance surveys (**Map 3.9-1**, BLM M. Read, pers. com. 2012).

Numerous historical records of black-footed ferrets have been documented within the project area (WYNDD 2007, WGFD 2007). Within the Continental Divide/Wamsutter II project area, two young black-footed ferrets were sighted in 1972 about five miles south of I-80; one adult was sighted in August 1975 in the northern portion; and a black-footed ferret skull was found in 1981 along the northeastern border. Wild-born black-footed ferrets currently exist in the Shirley Basin; at least 88 ferrets were observed during a partial survey conducted in 2004 (WGFD 2005b). Various barriers exist between the Shirley Basin black-footed ferret population and the project area, including highways (i.e., U.S. 287, I-80), mountain ranges (i.e., Freezeout, Shirley, and Seminoe), reservoirs (i.e., Pathfinder and Seminoe), and the North Platte River.

Greater sage-grouse is a sagebrush obligate found entirely in the western United States and Canada, primarily in the Intermountain West. Wyoming contains more sage-grouse than all other states combined. The species remains common in Wyoming because its habitat is relatively intact compared to other states. In south-central Wyoming, the harsh climate has limited habitat loss and conversion to settlements and agriculture. Historically, disturbance to greater sage-grouse habitat in south-central Wyoming has occurred as a result of livestock grazing, associated sagebrush-control treatments, and oil and gas development. Landscape-scale disturbance to this habitat has resulted more recently from the increased development of a variety of energy resources and the associated workforce. The greater sage-grouse is considered a sagebrush ecosystem umbrella species, which assumes that conserving its habitat will benefit other species of conservation concern that share the same habitats (i.e., pygmy rabbit, sage thrasher, and sage sparrow; Rowland *et al.* 2006).

Sage-grouse depend on extensive areas of sagebrush for food and cover throughout the year. Typically, strutting grounds or leks are located in open patches within sagebrush habitat and the surrounding area is considered potential nesting habitat. Nesting habitat tends to have higher sagebrush density, taller live and residual grasses, more live and residual grass cover, and little bare ground (Connelly *et al.* 2004). Sage-grouse are dependent upon sagebrush habitats for their year-round survival. This dependency includes using sagebrush for forage, nesting habitat, brood-rearing habitat, and winter thermal cover. In addition, sage-grouse require a variety of sagebrush habitat types to meet life-history requirements. Mesic habitats are also important for brood-rearing during the summer and fall months. The proximity of nesting habitat to brood-rearing habitat increases its value for broods, but may increase risk for nests (Dzialak *et al.* 2012).



Map 3.9-1. Black-footed ferret Non-Block Clearance areas and 2007 prairie-dog colony mapping area in and around the CD-C project area

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

Sage-grouse exhibit site fidelity to leks, winter and summer areas, and nesting areas (Schroeder *et al.* 1999). They may be affected by sagebrush community disturbance and removal. Sage-grouse tend to avoid areas that may provide perching or roosting opportunities for raptors (i.e., fence posts, power lines, and other structures) (Connelly *et al.* 2000 and 2004). Human activity during the breeding season may disrupt lek attendance and affect local breeding success. Populations across the west have declined from historic levels due to a wide range of factors including drought, habitat loss, and habitat degradation (Connelly and Braun 1997, Braun 1998, Connelly *et al*,. 2000 and 2004).

In 2004, the USFWS conducted a status review of greater sage-grouse throughout their range in response to petitions requesting the listing of the species under the ESA. On January 7, 2005, the USFWS determined that the greater sage-grouse did not warrant protection under the ESA. Nevertheless, on December 4, 2007, U.S. District Court Judge B. Lynn Winmill reversed the USFWS decision and remanded the case to the agency for further consideration. After another status review, the USFWS concluded in 2010 that the greater sage-grouse warranted protection under the ESA; however, ESA protection was precluded due to other species facing more immediate extinction threats (a warranted but precluded decision). As a result, the greater sage-grouse was added to the list of Candidate species under the ESA, which provides a status review every 12 months to determine if immediate attention is warranted.

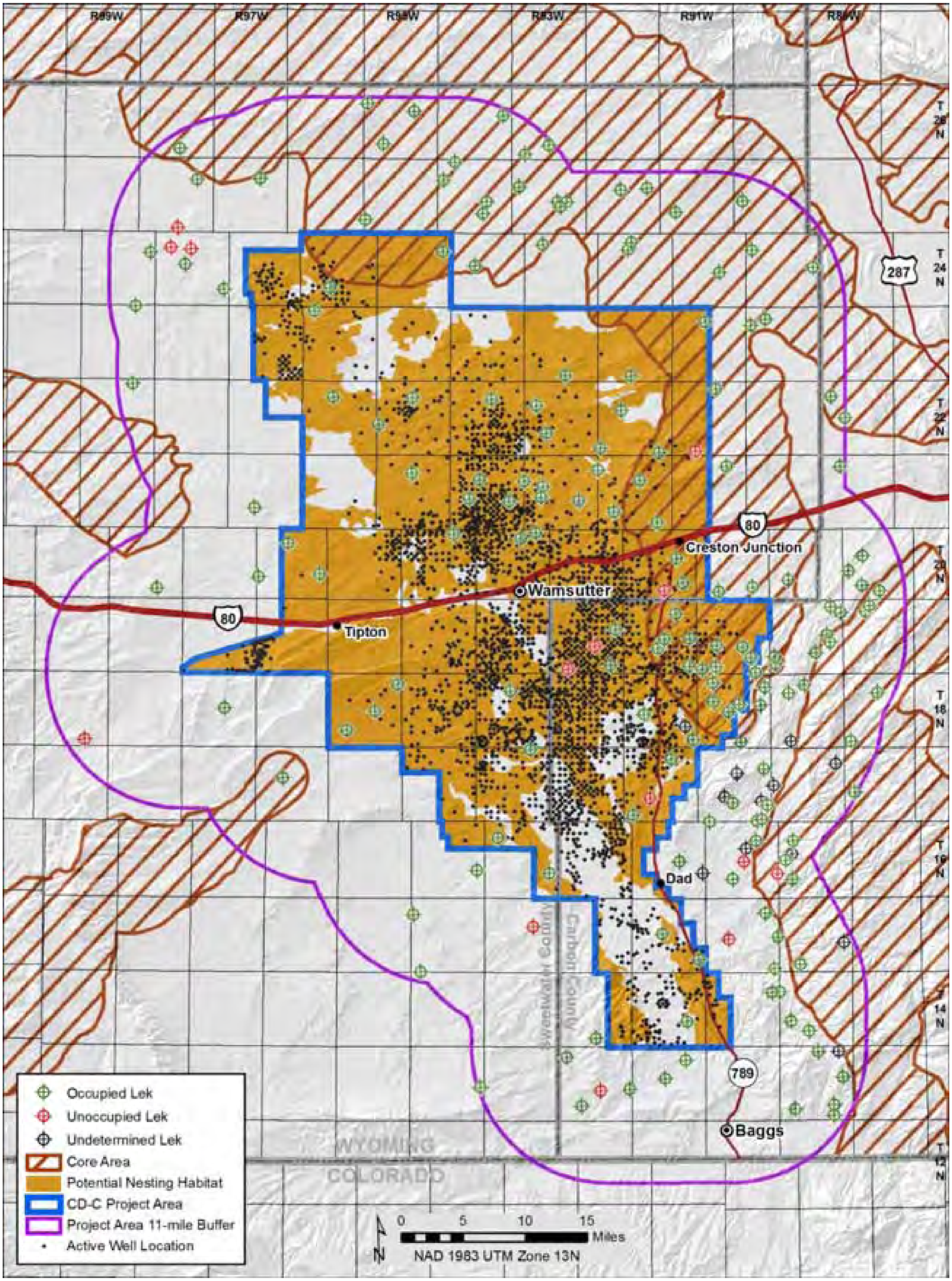
Although greater sage-grouse is currently a Candidate species, it receives no statutory protection under the ESA. However, certain conservation measures and stipulations are enforced by the BLM in accordance with BLM Sensitive Species management and by state agencies under the Statewide Executive Directive #2011-5 (SWED 2011, WGFD 2011c), Greater Sage-grouse Core Area Protection (SGEO) program. The SGEO enhanced habitat protection in sage-grouse core population areas on public as well as on private lands, when the activities on private land are subject to review or approval by state or federal statutes. In December 2011, BLM issued Instruction Memorandum (IM) 2012-043 (BLM 2012b) which provides rangewide interim management policies and procedures for conserving sage-grouse and their habitats. This IM reaffirms the application of the Wyoming Core Population Area Protection process, as follows:

> “The BLM field offices do not need to apply the conservation policies and procedures described in this IM in areas in which (1) a state and/or local regulatory mechanism has been developed for the conservation of the Greater Sage-Grouse in coordination and concurrence with the USFWS (including the Statewide Executive Directive 2011-5, Greater Sage-Grouse Core Area Protection); and (2) the state sage-grouse plan has subsequently been adopted by the BLM through the issuance of a state-level BLM IM.”

On February 10, 2012, the BLM released IM WY-2012-019, Greater Sage-Grouse Habitat Management Policy on Wyoming BLM Administered Public Lands Including the Federal Mineral Estate. This document provides guidance to BLM Wyoming field offices regarding management consideration of greater sage-grouse habitats for proposed activities until resource management planning updates are completed (BLM 2012c). The IM is consistent with IM WY-2012-043 (BLM 2012b) and is generally consistent with the SGEO (SWED 2011, WGFD 2011c). The conservation strategy for greater sage-grouse in the State of Wyoming continues to evolve. The Wyoming BLM is currently amending the Field Office RMPs regarding sage-grouse management and the requirements that would be applied to activities in sage-grouse habitat will change in accordance with those RMP amendments.

As required by IM WY-2012-019, an 11-mile analysis buffer is required around the project boundary for large-scale proposed actions (e.g. oil and gas full-field developments). According to the WGFD database, 192 known leks are located within 11 miles of the CD-C project area; 105 are occupied, 13 are unoccupied, and 74 have undetermined status (**Map 3.9-2**, WGFD 2010c). Leks are assigned an annual status of active, inactive, or unknown, and based on this leks are assigned a management status of occupied, unoccupied (destroyed or abandoned), or undetermined. Within 11 miles of the CD-C project area, there are approximately 546,600 acres of state-designated core population areas on BLM-managed land and 244,890 acres on state or private lands.

Prohibition of surface occupancy will be considered and evaluated by the BLM (2012c) and SGEO (SWED 2011) within 0.25 miles of non-core area leks and 0.6 miles of core area leks, measured from the perimeter of occupied or undetermined leks. Quarter-mile buffers around the perimeter of occupied or undetermined status leks located in non-core areas within the project area comprise approximately 3,072 acres (0.29 percent of the project area), which includes 1,215 acres of BLM, 0.17 acres of state, and 1,858 acres of private lands. The 0.6-mile buffers around the perimeter of occupied or undetermined status leks located in core areas within the project area compromise approximately 4,185 acres (0.3 percent of the project area), which includes 2,167 acres of BLM, zero acres of state, and 2,018 acres of private lands. BLM WY IM 2012-019 provides the following management actions for greater sage-grouse (BLM 2012c) and allows for local variation in the timing stipulation applicability dates.



Map 3.9-2. Greater sage-grouse potential nesting/brood-rearing habitat, leks, core areas, and 11-mile CD-C project area buffer

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

The Rawlins RMP timing stipulation dates are reflected below:

- In core population areas, surface-disturbing and disruptive activities will be prohibited in all nesting and early brood-rearing habitat, regardless of the distance from the nearest lek (**Map 3.9-2)** from March 1 to July 15 (BLM 2012, BLM 2008a).
- In non-core areas, surface-disturbing and disruptive activities will be prohibited within all identified nesting and brood-rearing habitat (Map 3.9-2) from March 1 to July 15 (BLM 2012, BLM 2008a).
- Surface-disturbing and/or disruptive activities are prohibited or restricted from November 15 – March 14 in mapped or modeled winter habitats/concentration areas (BLM 2012, BLM 2008a).
- Additional greater sage-grouse conservation measures that may be applied by the BLM can be found in the IM WY-2012-019 (BLM 2012c) and the Rawlins RMP.

BLM and other partners are working to develop statewide seasonal habitat models to identify important sage-grouse seasonal habitats. Until such time as those models are complete, and in the event there is a question that suitable nesting and early brood-rearing habitats exist in a particular area, the IM WY-2012-019 states that seasonal habitats will be determined using appropriate methods found in the Habitat Assessment Framework, or HAF. The Rawlins RMP (BLM 2008a, p. 2-55) states that surface-disturbing and/or disruptive activities are to be avoided in all identified nesting and early brood-rearing habitat (**Map 3.9-2)** from March 1 to July 15. The RFO also applies this level of protection to nesting and early brood-rearing habitat in non-core areas (M. Read, pers. com., February 2012). Currently, RFO wildlife biologists have defined “identified nesting and brood-rearing habitat” as any mesic shrub-dominated vegetative community (R. M. Etzelmiller, pers. com., May 2011). Map 3.9.3 provides an overview of areas where seasonal nesting and early brood-rearing restrictions would be applied unless site-specific field work indicates that nesting and early brood-rearing habitat is not actually present at a particular location.

Surface-disturbing and disruptive activities are defined in the Wyoming BLM Guidance for Use of Standardized Surface Use Definitions (WY Information Bulletin 2007-029). For sage-grouse, disruptive activity typically includes people and/or the activity in nesting habitats for a duration of one hour or more during a 24-hour period during the nesting season (BLM IM WO-2010-071 2010).

Greater sage-grouse populations are hunted in some areas of Wyoming, including the project area; the harvest from the South Central Conservation Area, which contains the project area (Upland Game Management Areas 9, 10, 24, 25, and 45), comprised 10.2 percent of the statewide yield in 2010 (**Table 3.9-2**; WGFD 2011). Since 1995, sage-grouse harvest numbers have been reduced by earlier opening dates, shorter hunting season length, and lower bag limits.

Table 3.9-2. Greater sage-grouse harvest numbers for the South Central Conservation Area

Year	Harvest (South Central)	Statewide Harvest	Percent of Statewide Harvest
1998	1,681	16,720	10.1
1999	1,931	21,407	9.0
2000	3,106	20,347	15.3
2001	1,641	12,577	13.0
2002	1,021	4,557	22.4
2003	664	4,835	13.7
2004	1,472	11,783	12.5
2005	2,519	13,178	19.1
2006	1,342	12,920	10.4
2007	1,163	10,378	12.1
2008	1,773	10,303	17.2
2009	1,619	11,162	14.5
2010	1,126	11,057	10.2

A sage-grouse population trend analysis (**Figure 3.9-1**) was conducted to compare sage-grouse populations associated with the CD-C project area to other related sage-grouse populations in southwestern Wyoming and the state as a whole. Specifically, the populations compared include (1) CD-C plus 11-mile analysis area, (2) the Core Population Areas affected by the CD-C project (Greater South Pass), (3) the statewide population, and (4) the "count" leks in the CD-C project area. The WGFD sage-grouse database (WGFD 2010) was used for this analysis. A count lek is a lek, designated by WGFD, on which the count lek protocol is performed annually. The count lek protocol is a survey method that is designed to give greater assurance that the actual peak male attendance is observed for that lek. There are five count leks related to CD-C; three are located in the east-central project area, one is in the northeast corner of the project area, and one is in the southeast corner. Average peak male attendance is used as an index of overall population size because the information is the most readily available and comprehensive. It has been suggested that a ratio of two hens per male in attendance could be used to determine the overall population size of grouse in an area. However, there have been a number of studies that call this ratio into question. Since it is not currently known what conversion factor should be used in the project area to achieve an accurate total population size, no attempt was made to do so here.

The year 1990 was chosen as a beginning point of the comparison analysis to demonstrate the cyclical nature of the species. Also during this period, throughout the state, sage-grouse survey and count protocols were improved and more consistently applied. As demonstrated in **Figure 3.9-1**, the population trend in all study groups is similar regardless of the size of the population involved. This comparison of four different groups of sage-grouse leks removes the question of local weather conditions affecting the population or the level of survey effort or of any one sub-set of leks affecting or controlling the overall trend.

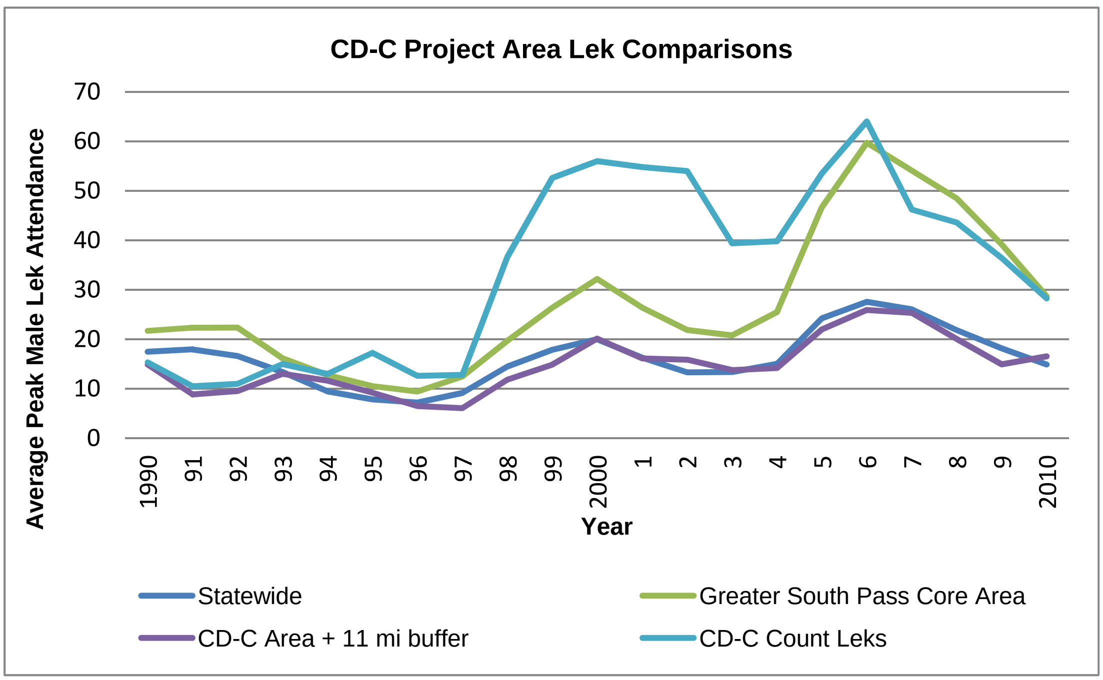


Figure 3.9-1. Average peak observed male attendance for leks associated with the project area (WGFD 2011)

As can be seen in **Figure 3.9-1**, all populations analyzed experienced similar increases and decreases in numbers of individuals observed. It is generally agreed (Connelly 2004) that sage-grouse populations are cyclical; **Figure 3.9-1** indicates an apparent seven-year cycle.

3.9.1.2 Threatened or Endangered Fish Species

Four federally Endangered fish species may occur as downstream residents of the Colorado River System: Colorado pikeminnow (*Ptychocheilus lucius*), bonytail (*Gila elegans*), humpback chub (*Gila cypha*), and razorback sucker (*Xyrauchen texanus*) (USFWS 2004a). The Colorado pikeminnow, bonytail, and humpback chub are all members of the minnow family. The razorback sucker is a member of the sucker family. All four of these fish species share similar habitat requirements and historically occupied the same river systems. Declines in populations of these species are mainly attributed to impacts of water development (e.g. dams and reservoirs) on natural temperature and flow regimes, creation of migration barriers, habitat fragmentation, the introduction of competitive and predatory non-native fishes, and the loss of inundated bottom lands and backwater areas (Minckley and Deacon 1991, USFWS 1993).

The last sighting of any of these fish species in the Little Snake River was of a single Colorado pikeminnow in 1990. No critical habitat for these species has been designated in Wyoming (Upper Colorado River Endangered Fish Recovery Program 1999). However, the potential for project-related reductions in water quantity and/or quality to these tributaries to the Colorado River warrant their inclusion in this document.

Bonytail. Habitat of the bonytail is primarily limited to narrow, deep, canyon-bound rivers with swift currents and whitewater areas (Valdez and Clemmer 1982, Archer *et al.* 1985, Upper Colorado River Endangered Fish Recovery Program 1999). With no known reproducing populations in the wild today, the bonytail is thought to be the rarest of the Endangered fishes in the Colorado River System.

The bonytail historically inhabited portions of the upper and lower Colorado River basins. Today in the upper Colorado River Basin, only small, disjunct populations of bonytail are thought to exist in the Yampa River in Dinosaur National Monument, in the Green River at Desolation and Gray canyons, in the Colorado River at the Colorado/Utah border, and in Cataract Canyon (Upper Colorado River Endangered Fish Recovery Program 1999).

Colorado pikeminnow. The Colorado pikeminnow is the largest member of the minnow family and occurs in swift, warm waters of the Colorado River basins. The species was once abundant in the mainstem of the Colorado River and most of its major tributaries throughout Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, California, and Mexico. It was known to occur historically in the Green River of Wyoming at least as far north as the City of Green River. In 1990, one adult was collected from the Little Snake River in Carbon County, Wyoming (Baxter and Stone 1995). Subsequent survey attempts to collect Colorado pikeminnow from this area of the Little Snake River by WGFD personnel failed to yield any other specimens.

Humpback chub. Habitat of the humpback chub is also limited to narrow, deep, canyon-bound rivers with swift currents and whitewater areas (Valdez and Clemmer 1982, Archer *et al.* 1985, Upper Colorado River Endangered Fish Recovery Program 1999).

The humpback chub was historically found throughout the Colorado River System and its tributaries, which are used for spawning (Valdez *et al.* 2000). It is estimated that the humpback chub currently occupies 68 percent of its original distribution in five independent populations that are thought to be stable (Valdez *et al.* 2000).

Razorback sucker. The razorback sucker is an omnivorous bottom-feeder and is one of the largest fishes in the sucker family. Adult razorback sucker habitat use varies depending on season and location. This species was once widespread throughout most of the Colorado River Basin from Wyoming to Mexico. Today in the Colorado River Basin, populations of razorback suckers are only found in the upper Green River in Utah, the lower Yampa River in Colorado, and occasionally in the Colorado River near Grand Junction (Upper Colorado River Endangered Fish Recovery Program 1999).

3.9.1.3 Threatened, Endangered, Proposed, Candidate, or Experimental Plant Species

The USFWS (2002) has determined that one threatened plant species, **Ute ladies'-tresses**, may potentially be present within the project area (**Table 3.9-1**). This species is not known to occur within the project area, but it may potentially be affected by the proposed project. The known locations of this species in Wyoming include Converse, Goshen, Laramie, and Niobrara Counties. This species is not known to occur within the project area and the likelihood of it occurring there is low for the following reasons: (1) much of the project area is very arid and there are few perennial streams; (2) the elevation of the project area is near the upper limit for the species; (3) very few moist riparian area meadows are present; (4) where present, the transition from stream margins to upland vegetation is abrupt; and (5) in Wyoming, the species has only been located in the eastern and southeastern portions of the state (Fertig 2000).

3.9.2 BLM Sensitive Species

The BLM has developed a Sensitive Species List for public lands in Wyoming (**Table 3.9-3**). The list includes species that are not listed as Endangered or Threatened by the USFWS but may be rare or declining in the state.. The objective of the Sensitive Species designation is to ensure that the overall welfare of these species is considered when undertaking actions on public lands**,** and that these actions do not contribute to the need to list the species under the provisions of the ESA. It is the intent of this policy to emphasize the inventory, planning consideration, management implementation, monitoring, and information exchange for the sensitive species on the list. The BLM Sensitive Species List is meant to be dynamic and is reviewed annually with recommendations from BLM and appropriate non-BLM authorities for additions and deletions (BLM 2010). Twenty-eight species on the BLM Sensitive Species List that occur in the RFO may occur in or near the CD-C project area.

Table 3.9-3. Occurrence potential and habitat associations of BLM Sensitive Species within or near the CD-C project area

Common Name	Scientific Name	Occurrence Potential[1]	Habitat Association[2]
Mammals			
Fringed myotis	*Myotis thysanodes*	pp	Caves, forest, shrublands
Long-eared myotis	*Myotis evotis*	U	Caves, forest, shrublands
Pygmy rabbit	*Brachylagus idahoensis*	P	Sagebrush
Spotted bat	*Euderma maculatum*	pp	Cliffs, sagebrush
Swift fox	*Vulpes velox*	pp	Grasslands
Townsend's big-eared bat	*Corynorhinus townsendii*	pp	Caves, forest, shrublands
White-tailed prairie dog	*Cynomys leucurus*	P	Sagebrush-grasslands
Wyoming pocket gopher	*Thomomys clusius*	P	Sagebrush-grasslands
Birds			
Bald eagle	*Haliaeetus leucocephalus*	P	Rivers, stream and lakes
Brewer's Sparrow	*Spizella breweri*	P	Sagebrush
Burrowing owl	*Athene cunicularia*	P	Grasslands
Ferruginous hawk	*Buteo regalis*	P	Sagebrush-grasslands
Loggerhead shrike	*Lanius ludovicianus*	P	Shrublands
Long-billed curlew	*Numenius americanus*	P	Grasslands
Mountain plover	*Charadrius montanus*	P	Grasslands
Peregrine falcon	*Falco peregrinus*	U	Cliffs, rivers
Sage sparrow	*Amphispiza belli*	P	Sagebrush
Sage thrasher	*Oreoscoptes montanus*	P	Sagebrush

Table 3.9-3. Occurrence potential and habitat associations of BLM Sensitive Species within or near the CD-C project area, *continued*

Common Name	Scientific Name	Occurrence Potential[1]	Habitat Association[2]
Amphibians			
Great Basin spadefoot	*Spea intermontana*	P	Sagebrush
Northern leopard frog	*Rana pipiens*	pp	Plains and foothills ponds
Fish			
Roundtail chub	*Gila robusta*	P	Rivers, stream and lakes
Bluehead sucker	*Catostomus discobobulus*	P	All waters
Flannelmouth sucker	*Catostomus latipinnis*	P	Rivers, stream and lakes
Colorado River cutthroat trout	*Onchorhynchus clarki pleuriticus*	pp	Mountain streams
Plants			
Meadow milkvetch	*Astragalus diversifolius*	P	Moist, salt-accumulating habitats such as alkaline meadows and playa shorelines
Cedar Rim thistle	*Cirsium aridum*	pp	Barren, chalky hills, gravelly slopes, and fine textured, sandy-shaley draws
Gibben's beardtongue	*Penstemon gibbensii*	pp	Barren south-facing slopes on loose sandy-clay derived from Brown's Park formation
Persistent sepal yellowcress	*Rorippia calcycina*	P	River banks and shorelines

[1] *Occurrence potential includes: present (P), potentially present (pp), unlikely (U), and very unlikely (VU);(WGFD 2004a; HWA, unpublished data).*
[2] *WGFD 2004a.*

3.9.2.1 Sensitive Wildlife Species

Twenty terrestrial species and four fish species designated by the BLM as Sensitive that occur in the RFO may occur in or near the CD-C project area and thus potentially could be affected by the Proposed Action (**Table 3.9-3**; BLM 2010, WGFD 2007, WYNDD 2007). The black-tailed prairie dog, Baird’s sparrow, Columbian sharp-tailed grouse, northern goshawk, trumpeter swan, white-faced ibis, hornyhead chub, and boreal toad are located within the RFO; however, they are not located nor do they have habitat within or near the CD-C project area.

Mammals

Fringed myotis. This bat species occupies a variety of coniferous forests, woodland chaparral, and basin-prairie shrubland habitats throughout western North America from British Columbia to southern Mexico. In Wyoming, its residency status is currently unknown (WGFD 2004a). This species could potentially utilize the project area for feeding; roosting sites may occur in the project area as suitable habitat (i.e., caves and mines) is present.

Long-eared myotis may hibernate in Wyoming, but the species is considered uncommon and its residency status currently is unknown (WGFD 2004a). Long-eared myotis has been documented approximately 15 miles west of the project area (WYNDD 2007). Suitable habitat for the species occurs in the project area.

Pygmy rabbit. A sagebrush obligate, the pygmy rabbit requires tall sagebrush and deep, soft soil for burrowing. Therefore, it is not distributed uniformly across the sagebrush shrub-steppe ecosystem. The species occurs in eight western states (California, Idaho, Montana, Nevada, Oregon, Utah, Washington and Wyoming), and has been documented throughout western Wyoming including Carbon and Sweetwater counties. It should be noted that the Columbia Basin Distinct Population Segment in

Washington State is managed differently and is currently listed as Endangered under the ESA. In September 2010, the USFWS released its 12-month finding on a petition to list the pygmy rabbit as Endangered or Threatened range-wide under the ESA and found that listing was not warranted. Although listing was not warranted, the USFWS acknowledged several threats to pygmy rabbit habitat including sagebrush conversion for agricultural purposes, livestock grazing, and energy development. Suitable pygmy rabbit habitat is patchily distributed but abundant in the Continental Divide Basin and surrounding areas. Pygmy rabbits have been documented throughout the project area (WYNDD 2007, HWA unpublished data).

Spotted bat. Although it occurs sporadically as a summer resident across the western United States, the spotted bat has not been documented in the project area (WGFD 2007, WYNDD 2007). Spotted bat is associated with juniper shrublands and desert-sagebrush grasslands in Wyoming (WGFD 2004a). The species may occur in the project area. Roosting habitat such as cliffs is present although perennial water is lacking.

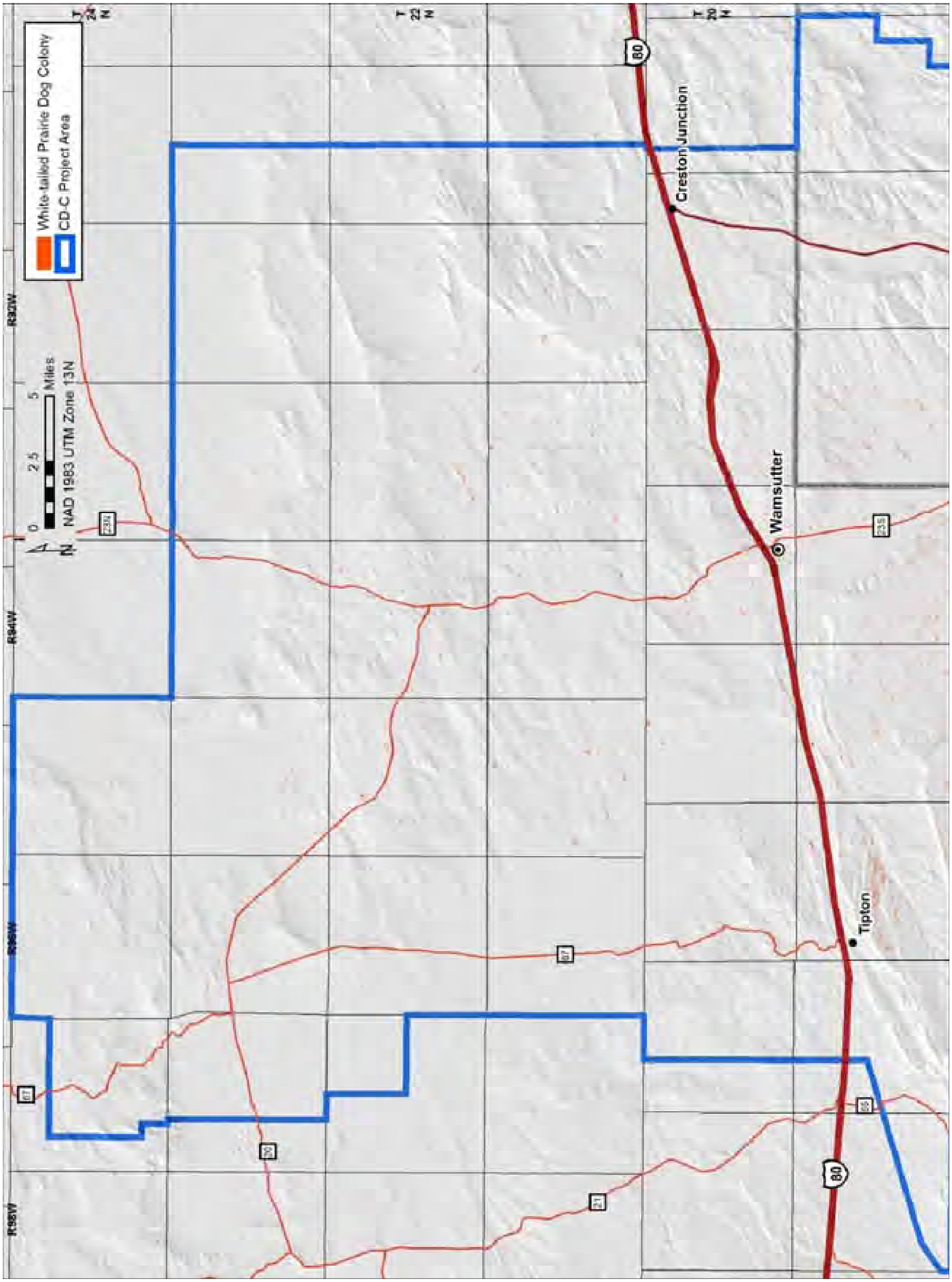
Swift fox. The swift fox inhabits short-grass and mixed-grass prairies over most of the Great Plains, including eastern Wyoming (Clark and Stromberg 1987). Studies have documented swift fox in Carbon and Sweetwater Counties within the project area and the species potentially may occur (Woolley *et al.* 1995). However, no swift fox have been documented in Sweetwater County in recent years (WGFD 2007, WYNDD 2007).

Townsend's big-eared bat can be found throughout Wyoming and its distribution is likely determined by the availability of roosts such as caves, mines, tunnels, and crevices with suitable temperatures (Clark and Stromberg 1987). Although its residency status is currently unknown, it may hibernate in Wyoming in caves (WGFD 2004a). This species has not been observed within or near the project area (WGFD 2007, WYNDD 2007). It may be present in the project area as forage and roosting habitat (caves, mines, rock outcrops, and buildings) are present.

White-tailed prairie dog. This species occupies grassland, sagebrush, and arid shrubland habitats in central and western Wyoming (Clark and Stromberg 1987) and is found in scattered colonies throughout the project area. Approximately 8,818 acres of white-tailed prairie-dog colonies have been mapped within the project area to date (**Map 3.9-3a and 3.9-3b**; BLM RFO unpublished data; HWA unpublished data).

Wyoming pocket gopher. Endemic to southeastern Sweetwater County and southwestern Carbon County, the Wyoming pocket gopher has been documented within the project area (WYNND 2007, HWA 2008 and 2009). Another population has been recorded in Carbon County approximately 20 miles east of the project area near Bridger's Pass, and the species may occur elsewhere (Clark and Stromberg 1987). In August 2007, the Wyoming pocket gopher was petitioned for listing under the ESA. The rationale for petitioning the species included a lack of knowledge regarding its taxonomy, abundance, population trends, distribution, habitat requirements, and the potential effects from energy development within their range. In April 2010, the USFWS determined the Wyoming pocket gopher did not warrant protection as a threatened or endangered species under the ESA.

As part of the survey efforts for the 12-month status review, HWA biologists collaborated with the BLM-RFO and WYNDD to conduct an extensive trapping effort during 2008 and 2009. The objective of the study was to capture Wyoming pocket gophers to genetically verify its status as a separate species, and to collect additional information on its distribution within the project area and across its predicted range in general. In 2008, 10 Wyoming pocket gophers and 20 northern pocket gophers were trapped in 351 trap-nights within the project area. Capture locations were concentrated within 15 miles southwest of Wamsutter on the plateaus above Wamsutter and Delaney Rims (HWA 2008c). In 2009, ten Wyoming pocket gophers and 12 northern pocket gophers were trapped in 550 trap nights within the project area. Capture locations were distributed throughout the project area, including eight captures approximately 20 miles southwest of Creston Junction (I-80 and WY 789) and two captures 10 miles north of Creston Junction (HWA 2009). Wyoming and northern pocket gophers appear to be sympatric (have overlapping ranges) within the project area.



Map 3.9-3a. White-tailed prairie-dog colonies within the CD-C project area

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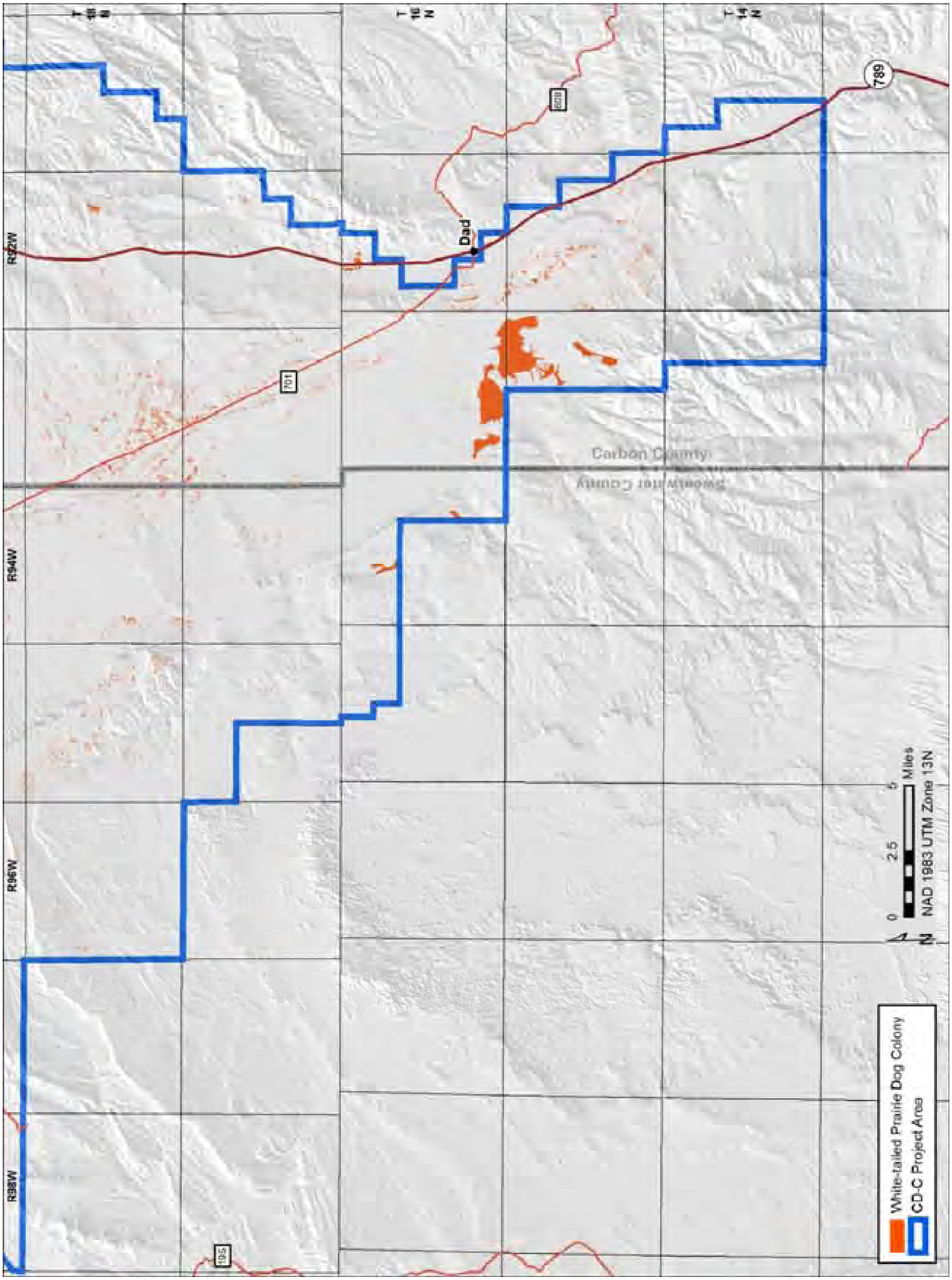

Map 3.9-3b. White-tailed prairie-dog colonies within the CD-C project area

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Birds

Bald eagle. This large North American eagle is normally found near water. It is found throughout North America, but primarily breeds in Canada, Alaska, the Pacific Northwest, the Rocky Mountains, and the Great Lakes region. Bald eagles have been observed in the project area primarily from November through March (WGFD 2004a, HWA unpublished data). The species may forage within the project area during the winter months because of carrion associated with pronghorn, mule deer, and elk winter ranges (**Maps 3.8-2**, **3.8-4**, and **3.8-6**). No bald eagle nests or nesting habitat (mature, large diameter trees near open water) occur within the project area. The nearest potential nesting habitat occurs along the Little Snake River approximately nine miles south of the project area.

Brewer's sparrow. A sagebrush obligate, Brewer's sparrow breeds throughout the intermountain west of the United States and winters in southern portions of California, Arizona, New Mexico, and western Texas, and south through the central part of Mexico (Rotenberry *et al.* 1999, Sibley 2000). Brewer's sparrows will breed in a variety of shrubland habitats, but prefer areas dominated by big sagebrush (*Artemisia tridentata*; Rotenberry *et al.* 1999). It prefers to nest in shrubs that are taller and denser than average (Petersen and Best 1985). This species may be particularly sensitive to habitat fragmentation, and appears to be affected more by changes at the landscape level than at the local level (Knick and Rotenberry 1995). Brewer's sparrow is expected to breed and has been observed within the project area (WGFD 2004a, WYNDD 2007, HWA unpublished data).

Burrowing owl. The burrowing owl is found throughout the plains and prairies of the western United States during the spring, summer, and fall (Haug *et al.* 1993). While the species has the capacity to excavate its own burrow, it seldom does, relying instead on mammals such as prairie dogs, ground squirrels, and badgers (Thomsen 1971). The burrowing owl's close association with burrowing mammals suggests dependence on them (Haug *et al.* 1993). Knowles (1999) suggested that the burrowing owl is a near prairie-dog obligate species because its distribution is so closely tied to that of prairie dogs. Burrowing owls also use isolated ground-squirrel and badger burrows in hillsides, and road borrow ditches.

Burrowing owl is listed as a species of special concern across Wyoming, as a consequence of long-term population declines (Haug *et al.* 1993). Because of the strong association between burrowing owls and prairie dogs, declines in the burrowing-owl population have been linked to many of the same factors associated with declining prairie-dog populations (i.e., rodent-eradication programs and habitat loss). Furthermore, long-term conservation of the burrowing owl will likely be closely linked to the conservation and preservation of prairie-dog complexes, and other burrowing mammals. Burrowing owl occurs and breeds within the project area (BLM 2007a, WGFD 2004a, WYNDD 2007, HWA unpublished data).

Ferruginous hawk. Primarily found in mixed-grass prairie and sagebrush steppe habitats during the spring, summer, and fall, the ferruginous hawk generally builds nests on rock outcrops, the ground, or cliff ledges. Although a small population overwinters in Wyoming, most individuals migrate south for the winter. Ferruginous hawks are common in south-central Wyoming and breed within the project area (BLM 2007a, WGFD 2006, WYNDD 2007). The western two-thirds of Carbon County hosts one of the highest nesting densities of ferruginous hawks within Wyoming (BLM 2007a). BLM records document the occurrence of 577 ferruginous hawk nest sites (**Table 3.8-5**; BLM unpublished data) in or within one mile of the project area.

Loggerhead shrike. This species breeds and winters throughout the United States in a wide variety of open habitats with some shrub or scattered-tree component. A summer resident, it usually builds its nest within large shrubs such as sagebrush, bitterbrush, or greasewood (Woods and Cade 1996). Loggerhead shrike populations have experienced declines across much of the species' range primarily due to loss of habitat. Livestock grazing in combination with drought is a major factor in the decline. In addition, the loggerhead shrike is prone to the negative effects of pesticide use because its diet consists largely of insects. The species is expected to breed and has been observed within the project area (WGFD 2006, WYNDD 2007, HWA unpublished data).

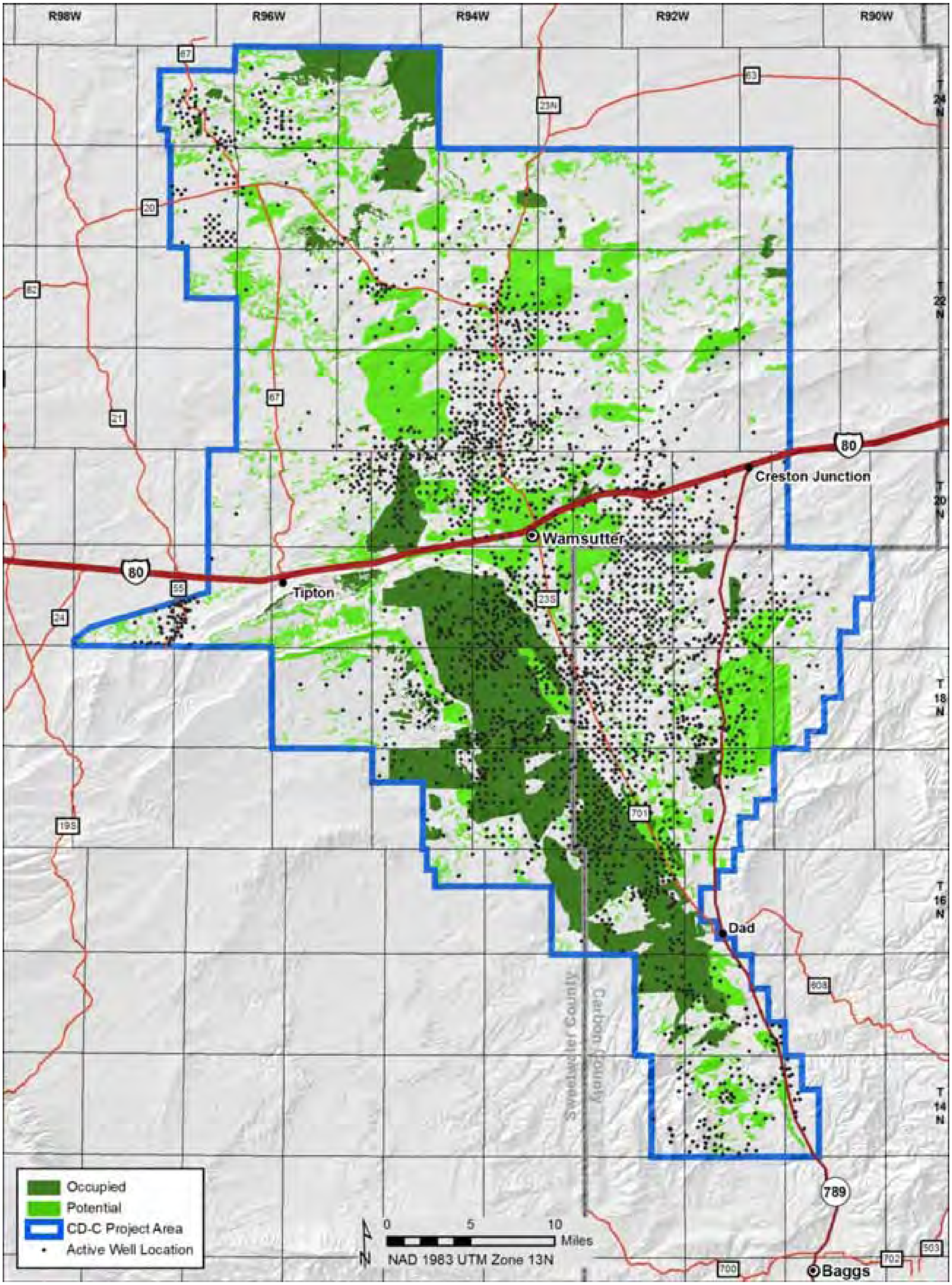
Long-billed curlew. A locally common summer resident of Wyoming (WGFD 2004a), the long-billed curlew prefers gentle, rolling topography in native grasslands, sagebrush, and agricultural lands that can be arid as long as a water source is relatively nearby. One observation of a long-billed curlew has been documented in the extreme south of the project area (WGFD 2006). It is unlikely the species breeds in the project area because suitable breeding habitat and water are limited.

Mountain plover. The mountain plover is dependent on short-grass prairie and also is frequently associated with prairie-dog towns (Knowles *et al*. 1982). The species nests on the ground in large grassland areas with short, sparse vegetation and substantial amounts of bare ground. In May 2011 the USFWS determined that the mountain plover is not threatened or endangered throughout all or a significant portion of its range. Numerous observations of mountain plovers have been recorded within the project area (WGFD 2007, BLM unpublished data, HWA unpublished data). Approximately 342,393 acres of occupied or potential mountain plover habitat have been mapped, comprising approximately 32 percent of the project area (**Map 3.9-4**; HWA unpublished data).

Peregrine falcon. The peregrine falcon breeds throughout North America, including the Arctic, the Pacific coast, the Rocky Mountains, and scattered areas across the eastern United States. Although populations of avian prey species in and around the project area may be abundant and diverse enough to support the species, breeding is unlikely due to the lack of high cliffs suitable for nesting. Nevertheless, peregrine falcons may be present within the project area during migration.

Sage sparrow. A sagebrush obligate found throughout much of the western United States, the sage sparrow breeds in sagebrush expanses from the northern edges of the Great Basin west of the Rocky Mountains to the chaparral and sagebrush scrub in Baja California (Martin and Carlson 1998). Suitable sagebrush habitat is widespread and abundant within the project area. The sage sparrow is expected to breed and has been observed within the project area (WGFD 2006, WYNDD 2007, HWA unpublished data).

Sage thrasher. A sagebrush obligate found throughout the intermountain west, the sage thrasher builds nests in shrub-steppe communities dominated by sagebrush. Suitable sagebrush habitat is widespread and abundant within the project area. The sage thrasher is expected to breed and has been documented within the project area (WGFD 2007, WYNDD 2007, HWA unpublished data).



Map 3.9-4. Occupied and potential mountain plover habitat within the CD-C project area

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Amphibians

Great Basin spadefoot. An occupant of sagebrush and greasewood communities as well as playas below 6,000 feet, the Great Basin spadefoot deposits eggs in springs or flooded areas formed by heavy rains (WGFD 2004a). Its life history requires suitable foraging areas, ephemeral breeding ponds, and overwintering sites. In the winter this species digs its own burrow and will overwinter underground, sometimes as deep as 15 feet. The Great Basin spadefoot has been documented in Sweetwater, Lincoln, Fremont, and Natrona Counties, and has been documented within the project area (Baxter and Stone 1992, WGFD 2006, WYNDD 2007). Playas and riparian areas within the project area likely support this species.

Northern leopard frog. This frog species is usually found close to wetlands, cattail marshes, and along vegetated shorelines during summer, but will venture several hundred meters along wet drainages during wet periods (Werner *et al.* 2004). A member of the true frog family (*Ranidae*), the northern leopard frog is an obligate of permanent water in the plains, foothills, and montane zones of Wyoming up to 9,000 feet above sea level (WGFD 2004a). This species has been documented within six miles of the project area and has a high probability of occurring in any area having perennial water (WYNDD 2007). The northern leopard frog was petitioned for listing under the ESA; in October 2011 the USFWS determined at listing was not warranted.

3.9.2.2 Sensitive Fish Species

Fish species that are not listed as Endangered or Threatened by the USFWS, but that may be rare or declining in the state, have been included on the BLM’s Wyoming Sensitive Species List (BLM 2002). The intent of the sensitive species status is to ensure that actions on BLM-administered lands consider the welfare of these species and do not contribute to the need to list any other species under the provisions of the Endangered Species Act (BLM 2001).

Four BLM Wyoming State sensitive fish species are known to occur in portions of streams on or adjacent to the project area. These include the roundtail chub (*Gila robusta*), bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*Catostomus latipinnis*), and Colorado River cutthroat trout (*Oncorhynchus clarki pleuriticus*) (WYNDD 2003, BLM 2002). The three non-game fish species (roundtail chub, bluehead sucker, flannelmouth sucker) have been found within Muddy Creek downstream, within, and upstream of the project area, and in Bitter Creek downstream of the project area (WGFD 1998, 2004c, 2007a). In general, all three species are associated with hard substrates and deep pool habitat (Bower 2005).

The Muddy Creek watershed is one of the few stream systems in Wyoming where these three native, non-game fish species exist together (WGFD 2004b) and the only watershed where these species and Colorado River cutthroat trout are known to coexist. It has also been designated as Aquatic Crucial Habitat by the WGFD because the area addresses Goal 1 of the WGFD Strategic Habitat Plan (WGFD 2009). Because of the high conservation value of Muddy Creek for these species, multiple studies have been conducted to increase understanding of their ecology in the creek. The BLM is a signatory to the range-wide (Wyoming and other states) conservation agreement and strategy for roundtail chub, bluehead sucker, and flannelmouth sucker where these three non-game species are present. The BLM, WGFD, and University of Wyoming completed a study to better characterize the abundance, distribution, behavior, habitat requirements and genetics of the three non-game sensitive species within the Muddy Creek watershed, which included part of the project area (Beatty 2005). The following is a summary of those study results for 2004.

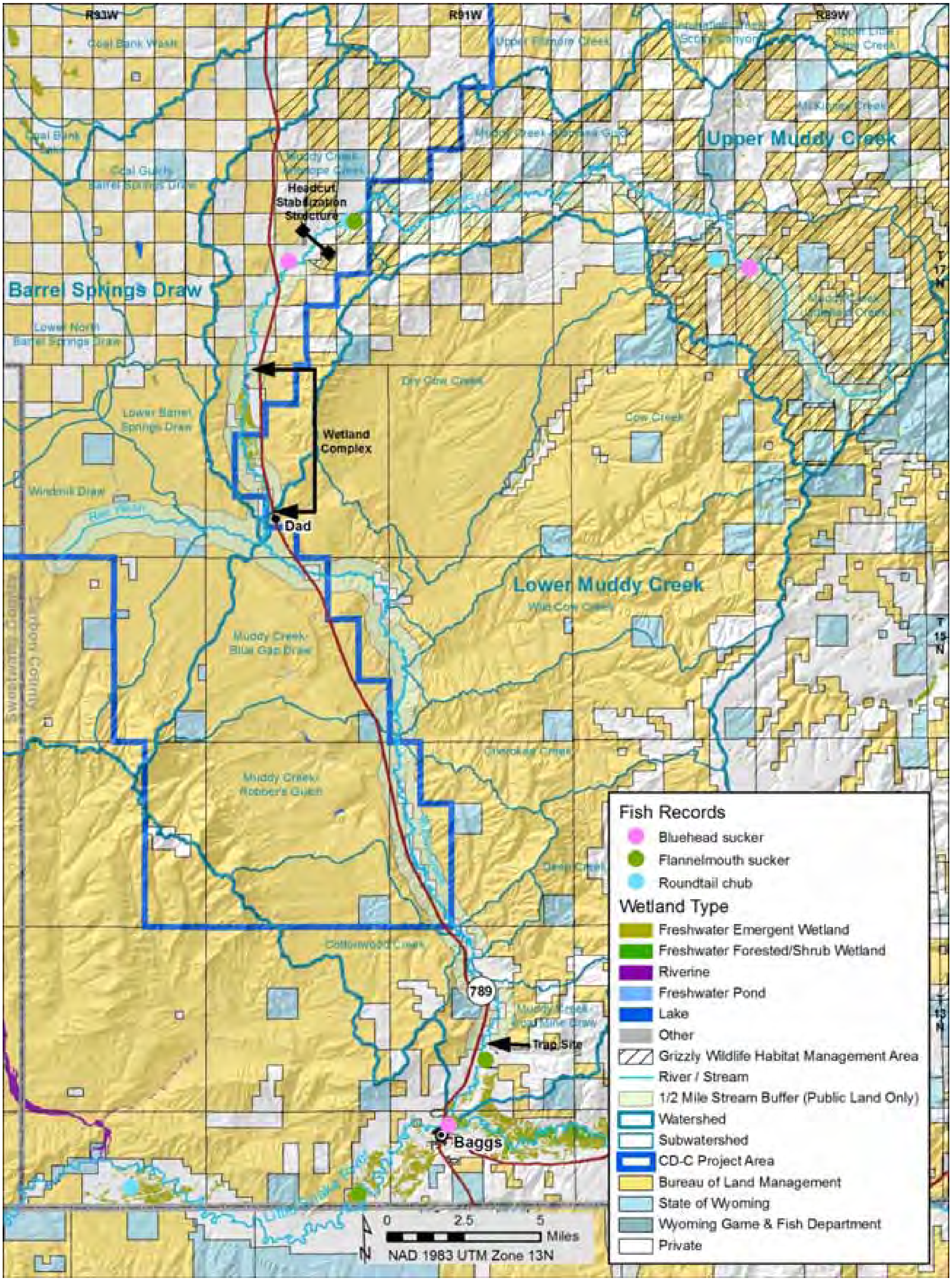
Man-made structures have resulted in three fragmented stream segments in the lower Muddy Creek watershed (Beatty 2005, **Map 3.9-5**). The farthest downstream segment (segment 1) begins at the confluence of Muddy Creek with the Little Snake River and extends upstream to a wetland complex with water-control structures that inhibit fish movement. The farthest downstream segment experiences periods of no surface flow with isolated pools and was dominated by non-native fishes in 2004. The middle segment (segment 2) consists of a wetland complex with numerous water-control structures and was dominated by non-native species, particularly the fathead minnow (*Pimephales promelas*). The upstream segment (segment 3) extended from upstream of the wetland complex to a headcut stabilization structure that prevents upstream movement by fish. The upstream segment was dominated by two native species: roundtail chub (*Gila robusta*) and speckled dace (*Rhinichthys osculus*). Constructed wetlands and barriers to upstream movements by fishes appear to influence native fishes and the structure of fish communities in lower Muddy Creek, similar to the effects of fragmentation and intermittent stream flows in other areas of the Colorado River Basin.

Compton (2007) completed a study on the effects of barriers on these three sensitive species in Muddy Creek upstream of the wetland complex. Instream structures prevented or severely limited upstream movements, but downstream movements over structures occurred. Within each segment in this study area, roundtail chubs were most abundant and flannelmouth suckers were least abundant among the three native species. A core population of the three native species existed in one segment and supported the highest densities of juveniles and adults and the broadest length ranges. Non-native white suckers, *Catostomus commersoni*, were the most abundant species in the study area. Their highest densities occurred in altered habitat. Substantial hybridization with the two native catostomid species was evident. Compton (2007) concluded that native fish populations in the most upstream segment may be at risk of extirpation due to low abundance and reproduction. Connectivity among habitats is required to carry out the life-cycles of native fishes and fragmentation by man-made structures is affecting their abundance and distribution patterns.

WGFD (2007a) sampled these three species in the Muddy Creek and Bitter Creek watersheds in 2006 as part of a study of these species within the Green River watershed in Wyoming. Of the three species, only roundtail chubs were found in lower Muddy Creek. However, flannelmouth sucker-white sucker hybrids were found there. In upper Muddy Creek within the CD-C project area, all three species were found as well as flannelmouth sucker-white sucker hybrids and blue sucker-white sucker hybrids. Flannelmouth suckers also were found in the headwaters of Bitter Creek. WGFD (2007a) concluded that perhaps the biggest threat to native bluehead and flannelmouth suckers in the Green River drainage of Wyoming is the occurrence of and subsequent hybridization with nonnative white sucker.

The Colorado River cutthroat trout, which is a native game fish, has been re-introduced into Muddy Creek upstream of the project area and into Littlefield Creek, a tributary to Muddy Creek, upstream of the project area. Before the introduction was made, all fish in these segments of these creeks were eliminated and a fish barrier was installed on Muddy Creek immediately upstream of McKinney Creek to prevent non-native fish from gaining access to the stream. In addition to the Colorado River cutthroat trout, the WGFD is planning to re-introduce all native species into the segment of Muddy Creek upstream of the barrier. Colorado River cutthroat trout also occur downstream from the project area in the Little Snake River (Baxter and Stone 1995). This species had been petitioned for listing as Threatened or Endangered; however, the decision “not warranted to list” was made in June 2007.

Besides Muddy Creek, all of the other streams on the project area are ephemeral and therefore do not have the potential to support BLM Wyoming State sensitive fish species on a year-round basis. Studies indicate that the non-game, native species may ascend ephemeral tributary streams to spawn (USFWS 1985, Maddux and Kepner 1988, Weiss *et al.* 1998). Thus, ephemeral drainages fed by runoff from the project area may provide habitat for sensitive fish on a seasonal basis.



Map 3.9-5. Lower Muddy Creek Watershed

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Bluehead sucker. Present in the Little Snake, Green, Snake, and Bear River basins in Wyoming (Baxter and Stone 1995, WGFD 1998, WGFD 2004a), the bluehead sucker occupies habitats similar to that of the roundtail chub. This species is considered rare in Wyoming in comparison with other sucker species. This species occurs in the Little Snake River and is found in Muddy Creek upstream of and within the project area (Baxter and Stone 1995, WGFD 1998, WGFD 2004a, Bower 2005, Beatty 2005, Compton 2007, WGFD 2007a). It has hybridized with non-indigenous white suckers (*Catostomus commersoni*) in Muddy Creek (Compton 2007, WGFD 2007a).

Colorado River cutthroat trout. This is the only trout native to the Green River and Little Snake River drainages in Wyoming (Baxter and Stone 1995). Historical records indicate it was present in Muddy Creek in the mid-1800s (Fowden, WGFD, personal communication). Historically, this subspecies inhabited clear-water tributaries of the Colorado River in Colorado, Utah, Wyoming, and probably also in New Mexico and Arizona (Behnke 1992). This species now occupies only a fraction of its former range. Some of the most genetically "pure" of the remaining populations of this trout subspecies are found in the Little Snake River upstream of the project area in Carbon County, Wyoming (Baxter and Stone 1995). Colorado River cutthroat trout have been re-introduced into Littlefield Creek and Muddy Creek upstream of the project area. Therefore, this species occasionally may occur within the project area, although suitable habitat is not present to sustain it. The species is generally associated with steep, clear, cold-water streams around rocky areas, riffles, deep pools, and near or under overhanging banks and logs (Binns 1977). Colorado River cutthroat trout have been extirpated from much of their original range through competition with brook trout, rainbow trout, and brown trout, and hybridization with rainbow trout (Binns 1977).

Flannelmouth sucker. One of the most abundant and widely distributed sensitive fish species of the tributaries and mainstream portions of the Upper Colorado River Basin, the flannelmouth sucker is found primarily in the Yampa, Little Snake, Colorado, Green, and Gunnison River. It is also common in Muddy Creek in Carbon County, Wyoming, upstream of and within the project area (Bower 2005, Beatty 2005, Compton 2007, WGFD 2007a). There is limited information on the life history of this species. The available information suggests that flannelmouth suckers utilize habitats in medium to large rivers and are seldom found in smaller creeks, doing poorly in impoundments (Lee *et al.* 1980, Baxter and Stone 1995, and Colorado Water Resources Research Institute [CWRRI] 2000). Causes for their decline include construction of mainstream dams, altered river flows and water temperatures, and hybridization with the white sucker (Minckley 1973). The species has hybridized with white suckers in Muddy Creek (Compton 2007, WGFD 2007a).

Roundtail chub. The roundtail chub is a close relative of the federally Endangered humpback chub and bonytail. Its habitat consists of warm streams and larger rivers, usually in areas with slow-flowing water adjacent to areas of faster current (CWRRI 2000). This species is common within the Little Snake River drainage and is found in Muddy Creek upstream of and within the project area (Baxter and Stone 1995, WGFD 1998, WGFD 2004a, Bower 2005, Beatty 2005, Compton 2007, WGFD 2007a).

3.9.2.3 Sensitive Plant Species

Four BLM sensitive plant species may potentially occur within the project area. Two of the species are known to occur within the project area (BLM 2002b, Heidel 2008). The names and probability of occurrence of these species are listed in **Table 3.9.1**. The following species are located within the RFO; however, they are not located nor do they have habitat within or near the CDC project area: Laramie columbine, Trelease's milkvetch, many-stemmed spider-flower, dune wild rye, limber pine, and Laramie false sagebrush.

Gibben's beardtongue. In Wyoming, the known occurrences of Gibben's beardtongue are confined to extreme southwest Carbon County and extreme southeast Sweetwater County near the state line. This plant has been documented approximately 9 miles west of the southern tip of the project area (WYNDD 2007) and it has the potential to likely occur within the project area. Gibben's beardtongue may occur in grass-dominated sites with scattered shrubs, semi-barren fringed sagebrush/thickspike wheatgrass communities with 15–20 percent vegetation cover, or on ashy slopes amid *Cercocarpus montanus*. It may also occur on outcrops of the Green River Formation on steep yellowish sandstone-shale slopes below caprock edges.

Cedar Rim Thistle is endemic to the Wind River and Green River basins of central Wyoming. This plant has the potential to occur in the project area; however, the species has not been found within the project area (WYNDD 2007).

Persistent sepal yellowcress is generally found along moist, sandy stream banks, stock ponds, and man-made reservoirs near the high-water line. This species was located by HWA near Lost Creek below Eagles Nest Spring during special status plant surveys during the 2006 and 2007 growing seasons (HWA 2008a). Results of the surveys indicate the occurrences of persistent sepal yellowcress are mainly associated with the Lost Creek drainage near the Eagles Nest Spring site in the northern portion of the project area.

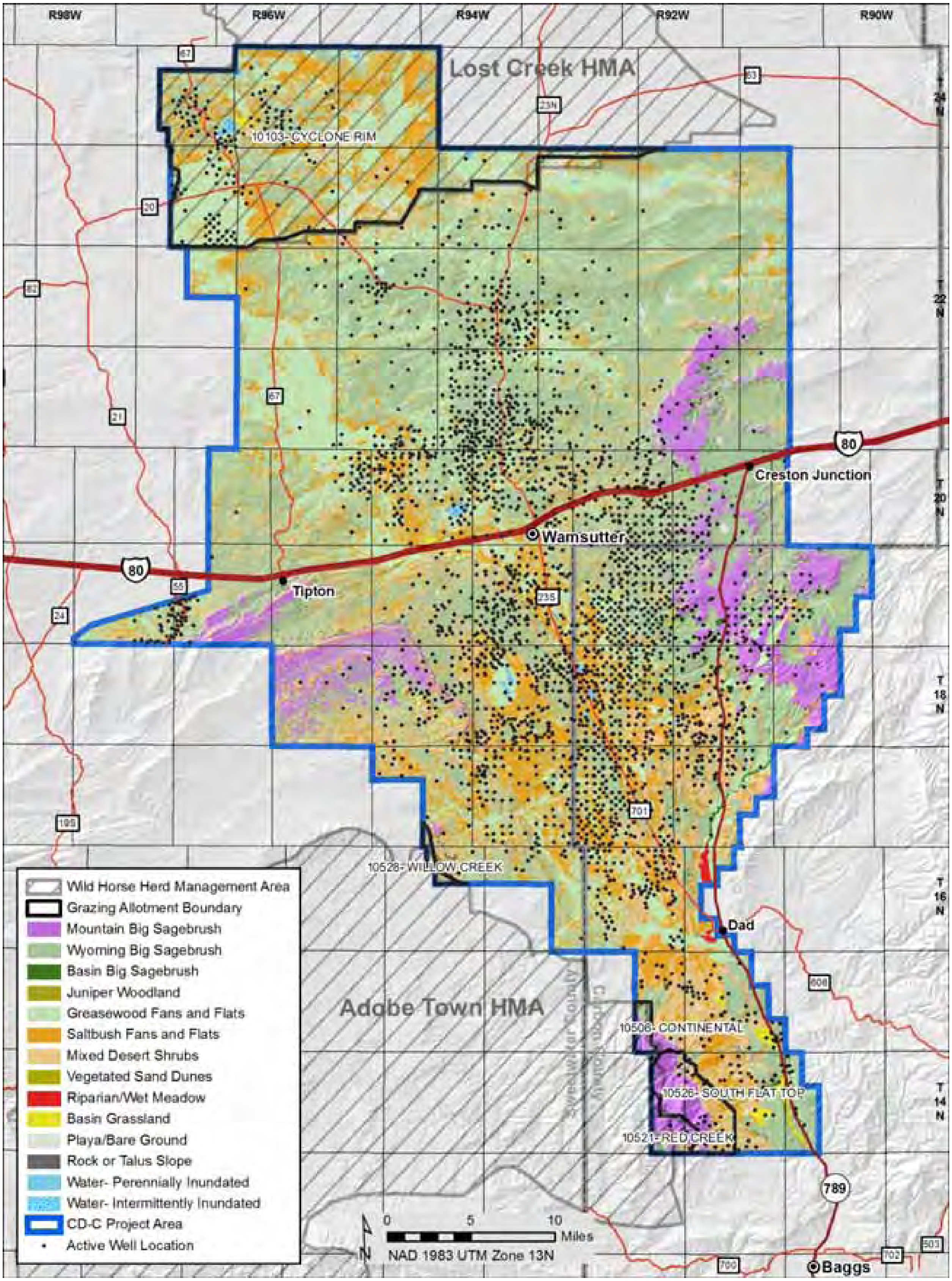
Meadow milkvetch is a perennial halophytic herb found in moist, salt-accumulating habitats. It is restricted to low topographic positions within the sagebrush zone of valleys and closed-basin drainages in alkaline meadows, playa shorelines, discharge zones, mounds, and shrub patches (Heidel 2008). The species has been documented in three extant occurrences in south-central Wyoming, totaling approximately 8,000 plants within about 187 acres, near the Chain Lakes region of the project area (Heidel 2009).

3.10 WILD HORSES

The Rawlins Field Office (RFO) maintains and manages wild horses (*Equus caballus*) in herd management areas (HMAs) and establishes an appropriate management level (AML) for each HMA. There are no wild burros within the project area and there will be no further discussion concerning wild burros in this EIS. The AML is the population objective for the HMA that will ensure an ecological balance for all users and resources of the HMA (e.g., wildlife, livestock, wild horses, vegetation, water, and soil). The current AMLs were established in 1994 from a process that included five years of focused and intensive monitoring, evaluation of data, public input, and environmental analysis (BLM 2005b).

The RFO has the responsibility to protect, manage, and control wild horses in its resource area pursuant to the Wild Horse and Burro Act of 1971 (Public Law 92-195). The wild-horse program is responsible for monitoring both the land and the herds, removing excess animals, and preparing animals for adoption.

The RFO manages three HMAs, two of which are partially located within the CD-C project area: the Lost Creek HMA and a small portion of the Adobe Town HMA (**Map 3.10-1**). The Lost Creek HMA encompasses approximately 251,000 acres, of which 235,000 are BLM-administered public lands. Of the BLM-administered total, approximately 119,600 acres of the HMA are located within the project area, virtually all of that acreage within the Cyclone Rim Grazing Allotment. The Lost Creek HMA is located within the closed Great Divide Basin with annual precipitation averaging a little less than six inches. With the exception of its northern border, all of the Lost Creek HMA surface area in the project area is located within the Cyclone Rim grazing allotment.



Map 3.10-1. Wild horse management areas within the CD-C project area in relation to major land cover types and affected grazing allotments

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The current AML for this HMA is approximately 60 to 82 horses which represents the high and low AML targets in relation to the gather-and-removal cycle. The current population estimate for the Lost Creek HMA is 120 adult animals (Mirati 2010). It was last gathered in the fall of 2009. The Lost Creek HMA is partially fenced from the checkerboard lands to the south. The Antelope Hills HMA adjoins the Lost Creek HMA to the north and is administered by the Lander Field Office.

The Adobe Town HMA is located approximately 20 miles west of Baggs, within Carbon and Sweetwater counties. The HMA encompasses approximately 472,812 acres, of which 444,744 acres are BLM-administered public lands. Of the BLM-administered total, approximately 5,826 acres of the HMA—1.2 percent of the total—are located within the CD-C project area (**Map 3.10-1**), including portions of the Continental, South Flat Top, Red Creek, and Willow Creek grazing allotments in the southwestern portion of the project area. Average annual precipitation in this area ranges from 7 inches in the desert basins to more than 12 inches at some of the higher locations. The current AML for this HMA is approximately 610 to 800 horses which represents the high and low AML targets in relation to the gather-and-removal cycle (BLM 2005b, updated June 2011).

The Salt Wells Creek HMA, managed by the Rock Springs Field Office (RSFO), adjoins the Adobe Town HMA to the west and both share a common, unfenced border. Past capture, census, and distribution data collected by both the RFO and RSFO indicate considerable movement and interchange takes place among the horses of these two HMAs (BLM 2005b). Consequently, both the RSFO and RFO work cooperatively to manage the two HMAs in the most efficient manner. The most recent gather of the Adobe Town/Salt Creek Complex was conducted in the fall of 2010 resulting in 1,939 horses removed from the complex. It is estimated that approximately 860 adult horses remain in this complex (Mirati 2010). In the majority of cases, wild horses have no natural enemies and population growth rates have been shown to be capable of 16- to 25-percent annual increases. This can result in a doubling of the wild-horse population every three to five years (BLM 2005b). However, in several instances, mountain lion (*Felis concolor*) predation has been documented to affect population growth rates (Turner and Morrison 2001). In the southern Great Basin of Nevada, mountain lion predation on the young was believed to be a major population-limiting factor (Greger and Romney 1999) with the recruitment-rate reduction due to take of foals. It seems reasonable to assume that historically, the gray wolf (*Canis lupis*) may have had the same effects on horse-population growth as reported for mountain lion. An unnatural cause, illegal killing, is also an unfortunate mortality agent. Where predation is not a factor, natural causes such as starvation, dehydration, disease, and injury are the primary wild-horse mortality agents. In a typical Rawlins wild-horse population, the highest mortality rates are for the young in their first winter (BLM 2005b).

Wild horses generally prefer perennial grass species as forage. Shrubs are more important during the fall and winter. On the CD-C project area, the species of grasses preferred depends on the season of the year. Needle-and-thread and Indian ricegrass are most important during the winter and spring, and wheat grasses during the summer and fall (BLM 2005b). Crane *et al.* (1997) determined that wild horses in south-central Wyoming spent about 61 percent of their daytime hours feeding and selected stream-sides, bogs/meadows, and mountain big sagebrush habitats over low sagebrush habitats. Sedges (*Carex* sp.) were an important component in the horses' spring/summer diet. This study concluded that palatability and abundance of graminoid vegetation and proximity to preferred habitats seemed to be the primary influences on habitat selection by wild horses within their study area.

Several studies address the question of direct competition (displacing a species when they arrive) and indirect competition (use of the same resources). Olsen and Hanson (1977) conducted a study to determine dietary overlaps and composition between wild horses, cattle, elk, sheep, and pronghorns in the Wyoming Red Desert. The percent of season dietary overlaps were most noticeable between wild horses, cattle, and elk. The study also showed that wild horses, cattle, and elk seemed to be tolerant of feeding on the same plants in different seasons and the strategy of grazing differed among species. Although this study only focused on the Red Desert area, there was enough variation in selection of diets between the different species that there was minimal overlap for the same resources.

In a similar study conducted in southeastern Oregon, McInnis and Vavra (1987) found that at least 88 percent of the mean annual diets of feral horses and cattle consisted of grasses. The researchers concluded that because dietary overlap between horses and cattle was high each season (62–78 percent), a strong potential existed for exploitive competition under conditions of limited forage availability (e.g., extended drought effects). McInnis and Vavra (1987) also determined in this two-year study that dietary overlap between horses and pronghorn varied from 7 percent (summer) to 26 percent (winter). Overlap between pronghorn and cattle varied from 8 percent (winter) to 25 percent (spring), suggesting that non-competitive coexistence (indirect competition) between pronghorn, wild horses, and cattle was possible at this level of dietary overlap. It is important to remember that even if species have the same diets, as long as there are adequate resource supplies there will be no competition. Only when resources are limited does direct competition occur.

Animal sizes vary and forage requirements change with the size of the animal. Similarly, different classes of livestock and different species of wildlife have varying requirements depending on size and maturity. Animal unit equivalents (AUEs) have been calculated for various kinds and sizes of animals. **Table 3.10-1** shows the most commonly used animal unit equivalents of various animal species in relation to a mature horse.

Table 3.10-1. Commonly used Animal Unit Equivalents

Class of Animal	Animal Unit Equivalent (AUE)
Cow, 1000 lb, dry	0.92
Cow, 1000 lb, with calf	1.00
Bull, mature	1.35
Cattle, 1 year old	0.60
Cattle, 2 years old	0.80
Horse, mature	***1.25***
Sheep, mature	0.20
Lamb, 1 year old	0.15
Goat, mature	0.15
Kid, 1 year old	0.10
Antelope, mature	0.20
Bison, mature	1.00
Deer, white-tailed, mature	0.15
Deer, mule, mature	0.20
Elk, mature	0.60
Sheep, bighorn, mature	0.20

■ HUMAN ENVIRONMENT

3.11 VISUAL RESOURCES

3.11.1 Visual Resources Characteristics

As described in **Section 3.1.1 Geology**, the CD-C project area is part of a semiarid desert dominated by patches and thickets of sagebrush. Along larger drainages, grasses, greasewood, brush, lichens, cottonwood, and other plants accompany the sagebrush stands. Colors of gray, brown, and olive characterize the vegetation, with grasses and forbs changing to shades of brown as they cure in the summer and fall. Soils and rock strata are shades of red, gray, and brown.

The project area is wholly within the Intermountain Semi-Desert Province of Southwestern Wyoming. North of Wamsutter, the project area lies within and comprises a large part of the Great Divide Basin section as a whole. The rest of the project area is almost entirely within the northeastern part of the Washakie Basin subsection of the Green River Basin section (Reiners and Thurston 1996). Rolling plains cover the Great Divide Basin part of the project area. The landscape is generally unbroken, so visual contrast draws attention wherever it occurs. Dune fields and playas (dry lakebeds) break up the sagebrush plain north of I-80. Elsewhere, cuestas (rims), occasional escarpments, and eroded streambeds create some visual contrast.

West of the Red Desert Road (BLM 3207) is a feature that USGS maps label the Red Desert Basin; this area possesses a pebbly soil with a distinctive reddishness that shows through the scattered sagebrush. The sand dunes of the northern part of the project area are part of a widespread dunes complex; dunes in the project area are mostly vegetated in contrast to the active, mostly bare dunes at Killpecker Creek, which is north of Rock Springs and far to the west of the project area.

The Chain Lakes Basin is part of a large playa complex that coincides with the Chain Lakes Wildlife Habitat Management Area in the northeastern part of the project area. Panoramic views of this area to the north of Chain Lakes Rim show these seasonal wetlands, which dry out to white alkaline flats. The occasional springs of Battle Springs Flat, west of Chain Lakes, support considerable greenery.

The extended Delaney Rim-Wamsutter Rim cuesta-and-valley complex divides the northern Great Divide Basin section of the project area from the Washakie Basin in the south. Panoramas of the central and northern portion of the project area present themselves from Delaney Rim, and the rim complex itself is the most prominent geologic feature visible from I-80 as the highway crosses the Great Divide Basin.

Eroded streambeds occur in the southern part of the project area; a key example is the deeply entrenched gully system in the lower reach of Muddy Creek. Little Robbers Gulch Reservoir, an agricultural pond far to the south within the project area, is a “social” recreation site (undeveloped and unmanaged) where usage fluctuates with the water level. Flat Top Mountain in the far south of the project area includes North Flat Top peak, the high point in the project area. This feature, Little Robbers Gulch, and The Bluffs are prominent geologic features visible from Wyoming Highway (WY) 789, the major north-south road through the southern part of the project area.

Cultural modification in the project area includes open disturbance, disturbed areas that are undergoing reclamation but do not yet blend into the landscape, and many structures. Visible in many parts of the project area are infrastructure (roads, power lines, and buried pipeline corridors), ranch improvements (homesteads, shearing sheds, fencing, and water impoundments) and oil and gas development (active drill sites and production and transportation facilities).

Oil and gas development, ongoing since the 1950s, comprises more than 4,400 natural gas wells in the project area. This surface disturbance is currently 49,218 acres (4.6 percent of the project area) of which 8,472 acres (0.8 percent) remain unvegetated and in use over the long term for facilities such as roads, well-production facilities, and pipeline facilities. The most common type of disturbance—more than 26,000 acres, or 2.4 percent—is from pipelines crossing the project area. An additional 10,958 acres have been disturbed for development other than oil and gas; this includes mainly federal, state, and county highways and roads, plus agricultural improvements.

The potentially affected scenic quality in the project area is low to moderate overall. Cultural modification due to oil and gas development has negatively affected scenic quality in seven of 15 identified landscape-rating units that are contained wholly or in part within the project area. This is generally because oil and gas development disturbs existing vegetation and introduces structures, with unnatural forms, lines, colors, and textures that contrast with the natural landscape character. In one of the seven landscape rating units found in the project area, the contrast introduced by existing oil and gas development is seen, attracts attention, and “in places is fairly dominant visually” (BLM 2011a).

I-80 bisects the project area from east to west. Because of high traffic volumes, I-80 is the vantage point from which potentially the most viewers see the project area. Views from I-80 are mainly of the Great Divide Basin portion of the project area, with the isolated mountains, uplands, and rims (among them Delaney Rim, as noted above) in the middle-ground, background, and skyline. Foreground and middle-ground views from the highway often contain residential, commercial, or industrial structures. Through travelers and trucks are the predominant users of I-80, and high prevailing speeds mean that motorists see any given part of the landscape for a short time.

Historically, WY 789 from Creston Junction to Baggs, Wyoming and Craig, Colorado, offered opportunities for pleasure driving and recreational access in the southern part of the project area. In the past five years, truck traffic on WY 789, mostly attributed to gas-field and interstate pipeline development, has grown almost twice as fast as other types of traffic. The Wyoming Department of Transportation (WYDOT) (**Section 3.16 Transportation**) now rates the traffic stream on WY 789 at less than “free-flowing.” Such traffic characteristics may discourage use of WY 789 for pleasure driving and sightseeing.

The principal county road through the project area—the Wamsutter–Dad/Wamsutter–Crooks Gap Road South (Carbon County Road [CCR] 701/Sweetwater County Road [SCR] 23S)—is now primarily a natural gas industry access road. This two-lane gravel road may be busier than any other road serving the project area except I-80. It receives high levels of heavy and overweight vehicle use, with truck traffic often moving at high speed and creating considerable dust (**Section 3.16 Transportation**). These characteristics now discourage use of this road for casual recreational use except as an access to other interior roads.

As described in **Section 3.16 Transportation**, almost all of the 33 other interior roads of the project area were originally intended for agricultural use, with consumptive wildlife recreation also being a common use that is traditionally related to agricultural landscapes and lifestyles. In recent years, the many interior roads have seen increasing use for natural gas industry access. Only three of 27 interior roads owned by BLM possess right-of-way agreements for all of the private lands that the roads cross. These are Road 3207 (Red Desert Road), Road 3316 (Robbers Gulch Road) and Road 3321 (Little Robber Road). Therefore, recreation is a historical and current use of the other 24 interior roads but is subject to private landowner decisions about access.

Because of the extensive road network, all land within the project area is in the foreground or middle ground of major or other roads (BLM 2011a). Increasing use by oil and gas workers lowers the level of sensitivity of many interior roads because of the low to moderate concern for scenic quality of most users in the context of low to moderate total use (BLM 2011a). For VRM sensitivity ratings, foreground and middle ground are treated alike and represent a distance of up to 3 to 5 miles (BLM 2011a).

The Overland Trail corridor through the project area is an exception because the trail corridor is identified as a special management area in the RFO’s RMP. The corridor has high sensitivity to scenic quality by definition because of its special area status and because of the interest it attracts as part of the most important historic trail in southern Wyoming (BLM 2011a). The trail corridor is described in **Section 3.14 Cultural and Historical Resources**.

3.11.2 Visual Resources Management System

Visual resources in the project area fall under the BLM's visual resource management (VRM) system. Guidance to manage visual resources is found in BLM Land Use Planning Handbook H-1601-1, Appendix C (BLM 2005c). Land use planning decisions mandate BLM to manage visual resource values in accordance with VRM objectives, which directly correspond to the assignment of all land to a VRM class. The BLM designates VRM classes for all land by inventorying the visual resources and by taking into account management considerations for other land uses. VRM classes may differ from VRM inventory classes because of management priorities for land use (BLM Land Use Planning Handbook H-1601-1, Appendix C, Page 11).

The BLM VRM classification system recognizes four VRM classes (Classes I through IV) based on scenic quality, visual sensitivity levels, and viewer distance zones. Each VRM classification has a management objective, as described below:

Class I. The objective of Class I is to preserve the existing character of the landscape. This class provides for natural ecological changes; however, it does not preclude very limited management activities. The level of change to the characteristic landscape should be very low and should not attract attention.

Class II. The objective of Class II is to retain the existing character of the landscape. The level of change to the landscape should be low. Management activities may be seen but should not attract the attention of the casual observer. Any changes to the landscape must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

Class III. The objective of Class III is to partially retain the existing character of the landscape. The level of change to the landscape should be moderate. Management activities may attract the attention of the casual observer but should not dominate the view of the casual observer. Changes should repeat the basic elements found in the predominant natural features of the characteristic landscape.

Class IV. The objective of Class IV is to provide for management activities that require major modifications to the existing character of the landscape. The level of change to the landscape can be high. The management activities may dominate the view and may be the major focus of viewer attention. Every attempt should be made to minimize the impact of these activities through careful location, minimal disturbance, and repetition of the basic visual elements of form, line, color, and texture.

3.11.3 Visual Resources Management Class Designations

VRM classes for the project area were established by the Rawlins RMP issued in December 2008. During preparation of the Approved RMP, a protest was lodged concerning visual resource values within the RFO. As a result, the BLM-preferred VRM decisions in the Proposed RMP/Final EIS were remanded, in accordance with guidance in the BLM Land Use Planning Handbook, H-1601-1.

Map 3.11-1 compares oil and gas development extant in the project area as of 2009 to the VRM classification set by the 1990 Great Divide Resource Management Plan (GDRMP) (BLM 1990). The 1990 GDRMP remained in effect as the RFO undertook the process of amending the RMP. Map 3.11-1 illustrates why there is a potential for conflict in jointly managing oil and gas development and visual resources in the RFO. The potential was identified by BLM in the GDRMP FEIS:

> The widespread development of petroleum, natural gas, and coal in the RMPPA is creating direct, negative visual impacts within the RMPPA. Currently, visual mitigation of this activity is preventing mineral development activities from exceeding the established VRM objectives within these areas. The trend toward continued expansion of natural resource development is creating areas of potential conflict between this activity and the established VRM class objectives . . . Utilities are also having

> an increasing visual impact in the RMPPA. Even buried fiber-optic lines leave obvious visual effects. …Although visual sensitivity is clearly not the highest priority for many residents and visitors, as increasing numbers of sightseers and persons seeking various types of recreational opportunities pass through the RMPPA, an awareness of scenic values and the existing scenic quality grows for some residents and visitors.

The RFO is in the process of updating the classification of its visual resources. However, until that process is complete, the RFO must, under the remand, use the VRM classification described in the No Action Alternative (Alternative 1) of the Proposed RMP/FEIS. **Map 3.11-1** reflects that classification scheme as it applies to the project area. The classification shown on Map 3.11-1 is simply the classification carried forward from the 1990 GDRMP.

As **Map 3.11-1** shows, the project area has mixed land-ownership. This means that some state and private land within a given VRM classification may not be subject to BLM administration, which applies only where the federal government owns the surface or the oil and gas beneath the surface. This distinction is reflected in the analysis of the land within the project area as presented in **Table 3.11-1**. About 60 percent of the total project area is VRM Class III; the remainder is VRM Class IV. However, BLM’s authority to manage visual resources is limited to an estimated 62 percent of the total land area in VRM Class III and 55 percent of the total land area in VRM Class IV. The remainder of the land in each class is exempt from BLM VRM management objectives because the surface and minerals are private or state owned.

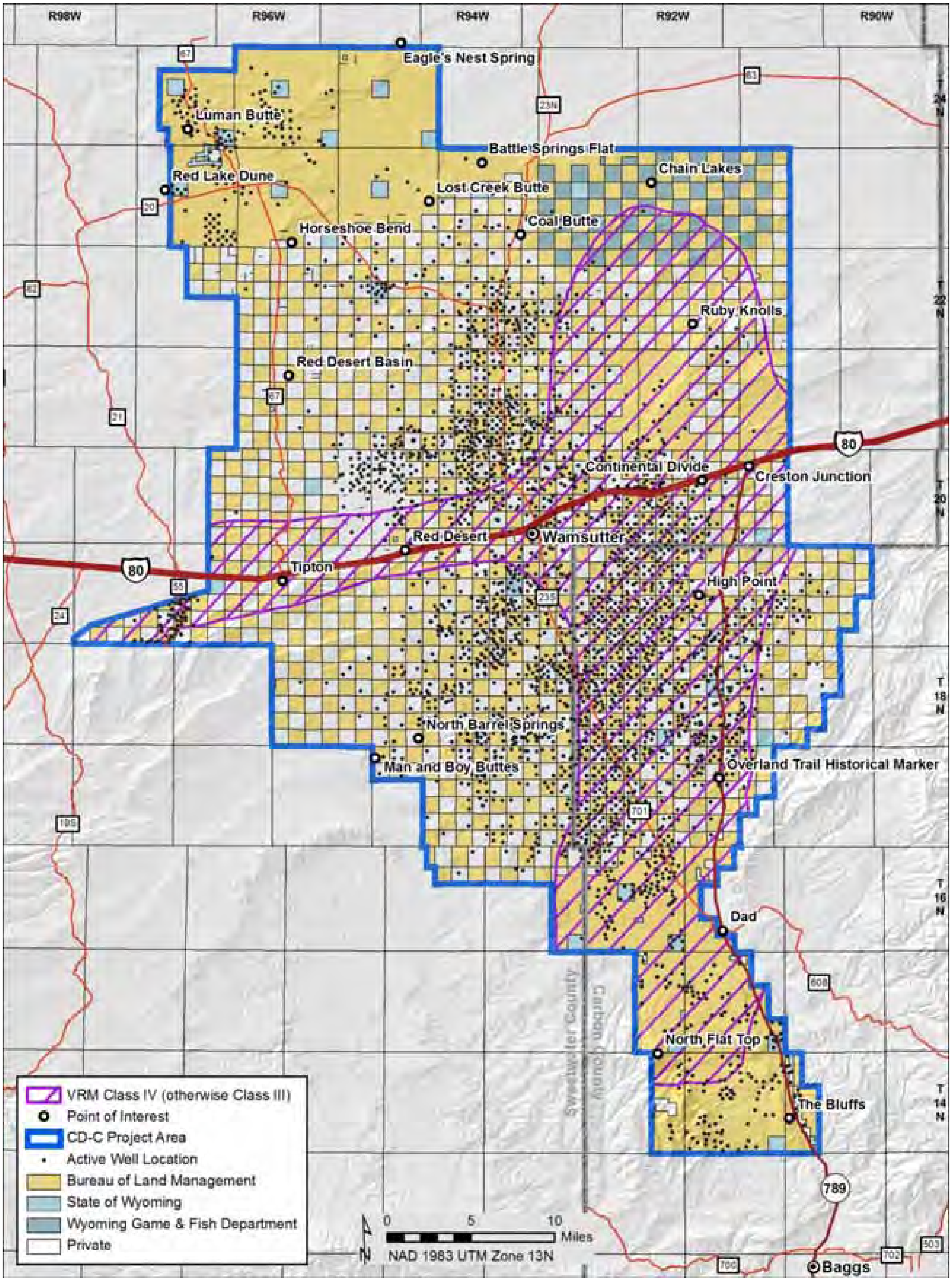
Table 3.11-1. Total and BLM-administered land area in the project area by VRM Class

VRM Class Designation	Land Area (thousands of acres)	VRM Class Share of Total Land Area	BLM-Administered Land (thousands of acres)	Share of BLM-Administered Land within Class
Class III	639	60%	393	62%
Class IV	431	40%	237	55%

3.11.4 Visual Resource Inventory of February 2011

The RFO began the process of updating its VRM objectives with a formal visual resource inventory (VRI) prepared in compliance with BLM Manual 8400, Visual Resource Management, and BLM Manual 8410, Visual Resource Inventory. The results of the completed inventory were published in February of 2011 (BLM 2011a). The publication of the updated VRI completes the first step of the process called for by the administrative remand described in Section 3.11.3 above. Using the updated inventory as a baseline, further steps remain to be completed to amend the RMP and to update the VRM classifications of BLM-administered lands in the RFO.

Information from the published VRI (BLM 2011a) has been used in this section to describe and characterize the affected visual resource environment of the CD-C project area as it exists now. However, the evaluations found in the inventory are not to be considered a VRM classification now or even, perhaps, the VRM classification that may be enacted in the future. No re-classification may occur until the RFO completes the entire RMP amendment process. Until then, as noted in Section 3.11.3, the RFO must use the 1990 VRM classifications.



Map 3.11-1. Current VRM Classification of land within the CD-C project area with comparison to existing well development

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

3.11.5 Visual Resources Management RMP Amendment

As noted in **Section 3.11.**3, the BLM completed the RFO RMP revision in December 2008, but a protest was lodged concerning visual resource values within the RMP planning area, which includes the CD-C project area. To resolve the protest issue, the RFO is conducting additional planning, beginning with the update of the RFO visual resource inventory described in **Section 3.11.4**.[10]

In April of 2012 BLM published a formal Notice of Intent (NOI) (Federal Register 2012a) to prepare an amendment to the VRM sections of the RFO RMP along with the required environmental assessment (EA) and began the amendment process with a 30-day public scoping period that ended May 11, 2012. The BLM intends to finalize the EA and VRM amendment by the end of 2013.

3.12 RECREATION

3.12.1 Recreation Resources

The main recreation resource of the project area is the public land managed by the BLM and the WGFD. This section discusses their use primarily for hunting and secondarily for pleasure driving to view wildlife, especially wild horses. No developed recreation sites exist within the CD-C project area. Dispersed recreational activity occurs wherever resources and access afford the opportunity. There is one undeveloped recreation site near the southern boundary of the project area, Little Robbers Gulch Reservoir, which has been historically used as a group hunting camp and fishing hole.

The project area is entirely within the Western Extensive Recreation Management Area (ERMA), a management classification of the RFO established by the Rawlins RMP. For the Western ERMA, the Rawlins RMP directs management to consider three recreation objectives: (1) provide for the health and safety of visitors, (2) prevent or mitigate resource damage resulting from recreation uses, and (3) *coordinate* with other programs to minimize conflicts and adverse impacts on recreational opportunities [emphasis supplied].

The project area is not part of any of the Special Recreation Management Areas (SRMAs) otherwise designated by the Rawlins RMP. This means that none of the areas with a high priority for recreation management in the RFO are to be found in the project area. The only feature in the project area that has a recreational aspect, and for which there is an explicit management directive in the Rawlins RMP with implications for recreational use, is the undeveloped recreation site at Little Robbers Gulch Reservoir.

One prescribed management action is targeted towards undeveloped recreation sites, such as Little Robbers Gulch Reservoir: the action opens a recreation site and its surrounding quarter-mile area to future oil and gas leasing with a “no surface occupancy” (NSO) stipulation. This means development of minerals directly under the restricted area may be undertaken by locating the necessary facilities outside of the restricted area. Although this primarily agricultural reservoir historically has been used as a hunters’ camp and fishing hole, it has recently been used less than in the past because of fluctuation in the water level.

BLM considers most of the project area to be Front Country, where improved roads are generally within 1/2 mile of recreation activity. This character prevails because of numerous improved roads in the Western ERMA that have been developed for oil and gas. Front Country is the second-most abundant class of recreation lands in the RFO according to the Rawlins RMP (BLM 2008a). Management affecting the Front Country recreation settings in the project area is guided by the objectives and actions

[10] This additional planning will not include the decision area for the Chokecherry/Sierra Madre wind energy project because a VRM amendment to the Rawlins RMP was considered separately as part of the NEPA process associated with the review of the Chokecherry/Sierra Madre wind energy project.

enumerated in the Rawlins RMP as described above. Indirectly, the recreation setting is affected by the VRM objectives established for the project area by the Rawlins RMP because the visual quality of an area is an important physical and social attribute of a recreation setting. (The Affected Environment for Visual Resources is described in **Section 3.11** and Environmental Consequences for Visual Resources are described in **Section 4.11**.).

3.12.1.1 Wildlife Resources

The existing environment for wildlife in the project area is discussed in **Section 3.8 Wildlife**. The big game wildlife resource supports hunting, which is the main recreation use of the project area. Hunting in the project area is mainly for pronghorn, but hunters also pursue mule deer and elk. Wild-horse viewing is another wildlife recreation use in the project area.

Commercial hunting guides using BLM land in the project area do so by obtaining a Special Recreation Permit (SRP) from the RFO. Nineteen hunting guides who hold permits to hunt on the WGFD Hunt Areas that overlap the project area also hold SRPs in the RFO. The project area is likely to be a small percentage of the total area upon which these hunting guides base their commercial operations. Information for determining the amount of use by these guides in the project area is not available from BLM records.

A main hunting resource in the northern part of the project area is the Chain Lakes Wildlife Habitat Management Area (WHMA) about 32 miles northwest of Rawlins. The Chain Lakes WHMA provides winter habitat and a seasonal migration corridor for pronghorn. Agreements provide hunter access throughout the WHMA despite its location in the “checkerboard,” the area of alternating one-square-mile sections of public and private land. By agreement with the WGFD, the Rawlins RMP opens the WHMA to future oil and gas leasing but with intensive management of surface-disturbing and disruptive activities. The wildlife resources of the northern part of the project area also include a block of about 135,000 acres of contiguous public land northwest of the WHMA (WGFD 2007b).

Wildlife resources in the southern part of the project area include the WGFD Carbon County Walk-In Area #1 located six miles southeast of Creston Junction. The WGFD walk-in program allows hunters to enter private land sections in the checkerboard without prior permission. The project area contains 15 sections of Walk-In Area #1 (9,600 acres), about half of which are privately owned. The remainder is outside of the project area, where it adjoins the 25,600-acre Red Rim-Daley WHMA, also located in the checkerboard of intermingled public and private land. Ready access for recreation is also available in the southern tip of the project area where there is another large, continuous block of public land. This block of public land includes upland habitat in the Flat Top Mountain range and its larger drainages, Blue Gap Draw, Robbers Gulch, and Little Robbers Gulch. Little Robbers Gulch also contains the undeveloped recreation site used as a hunters’ camp at Little Robbers Gulch Reservoir, as described above.

3.12.1.2 Other Recreation Resources

A network of small roads and two-tracks covers the project area. Increasingly, traffic has come to be dominated by vehicles related to oil and gas field-development and maintenance, but the roads continue to be used for range management and recreation. Full public access for all uses, including recreation, is available on I-80, WY 789, and Carbon and Sweetwater County roads. The BLM interior road network comprises 27 numbered routes. However, casual use without permission is limited to three roads where the BLM possesses full right-of-way agreements. These include Road 3207 (Red Desert Road), Road 3316 (Robbers Gulch Road) and Road 3321 (Little Robber Road). Private resource roads comprising the interior network of areas with gas development are generally open to the public.

Recreational off-highway vehicle (OHV) use occurs in the project area; however, such OHV use is typically for the scouting activity that is ancillary to big game hunting rather than it being a primary recreation activity.

Non-consumptive use, which is mostly driving the roads to view wild horses or the Red Desert landscape, is much less common than hunting. The resources that support these activities are located north of I-80 and are accessed from SCR 67 (Tipton-North Road) and BLM Road 3207 (Red Desert Road). Flat Top Mountain in the project area south of I-80 also attracts some recreation because of the visual resource (sightseeing, painting and photography of the mountain and from the overlooks it provides) and by the recreational setting (OHV, snowmobiling, and non-motorized snow recreation).

The Overland Historic Trail runs east and west across the southern part of the project area. Signage calls attention to a turnout with an interpretive plaque on WY 789 about 20 miles south of Creston Junction. This minor feature may attract sightseeing visits by trail enthusiasts. However, this is the only public access to the trail corridor in the project area.

3.12.2 Recreational Use

The BLM estimates recreation usage at the field-office level, so there are no data available on recreation participation and recreation visitor days specific to the CD-C project area. Relying on experience, field-office personnel characterize recreation use in the project area as low overall and seasonal during the year, with most recreational use occurring during the fall big-game hunting seasons.

The BLM generally views the project area as serving a statewide market for undeveloped recreation, especially the market comprising residents of Carbon County and nearby counties. However, there is considerable use of the area by non-resident hunters, especially pronghorn and mule deer hunters who are 23 percent and 27 percent non-residents, respectively. The project area also occasionally attracts non-resident recreation users with special interests such as wild horses, the Red Desert landscape, and historic trails. Recreation in the project area is shown on **Map 3.12-1**.

Table 3.12-1 presents data on hunting activity that indicate the level of hunting potentially occurring within the project area. The table shows the totals for the Hunt Areas that include the project area because the WGFD does not have information on sub-areas within Hunt Areas (WGFD 2010b).

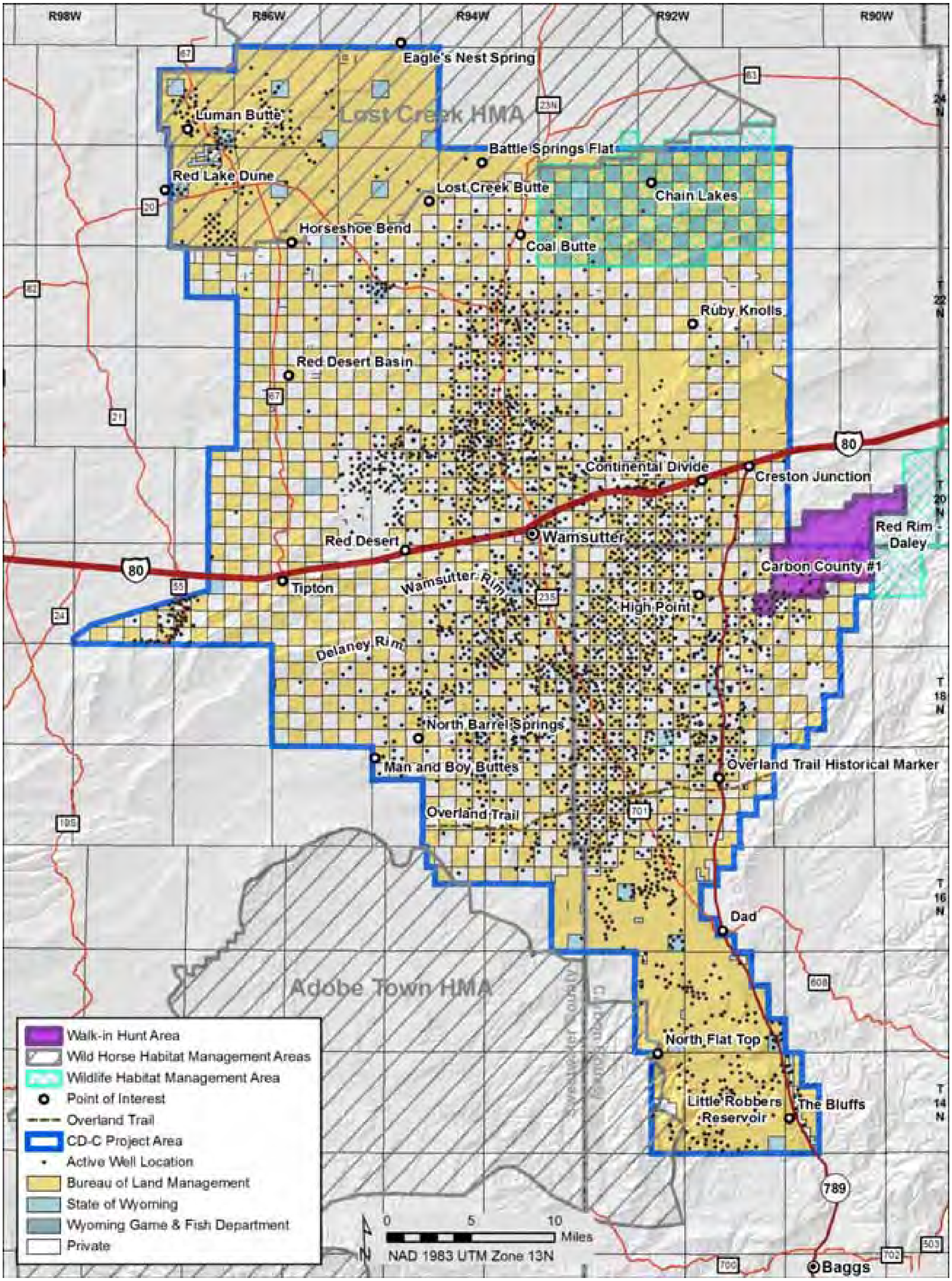
Table 3.12-1. Indicators of hunting activity by species in WGFD Hunt Areas that include the CD-C project area, 2009

Game Species	Hunt Areas Involved (% of Hunt Area overlapping the project area)	Total Active Hunters	Average Non-Resident Hunters	Average Hunter Success	Average Days per Hunter	Number of BLM-Permitted Commercial Outfitters[1]
Pronghorn Antelope	53 Baggs (2%) 55 Red Rim (28%) 57 S. Wamsutter (38%) 60 Table Rock (33%) 61 Chain Lakes (31%)	694	23%	92%	2.6	55
Mule Deer	82 Baggs (2%) 84 Atlantic Rim (19%) 98 Chain Lakes (31%) 100 S. Wamsutter (38%) 131 Steamboat (13%)	4,646	27%	45%	4.1	55
Elk	21 Baggs (2%) 100 Steamboat (14%) 108 S. Rawlins (19%) 118 Shamrock Hills (31%) 124 Powder Rim (23%)	3,057	16%	47%	5.9	55

[1] *Typical number of Special Recreation Permits for Rawlins Field Office. This number changes year to year and an exact number is not known due to the fact that other field offices hold permits for this area and little data was kept for any permit issued before 2007.*

Source: WGFD Annual Report of Big & Trophy Game Harvest 2009. Rawlins Field Office for Number of BLM-permitted Commercial Outfitters. Analysis by Lloyd Levy Consulting LLC.

An estimate based on map analysis is provided of the percentage of each Hunt Area that overlaps the CD-C project area. In terms of acreage, the project area contains about 28 percent of the involved Hunt Areas and 22 percent of the involved Herd Units for pronghorn (the Baggs, Bitter Creek, and Red Desert Herd Units). Similarly, the project area contains about 20 percent of both the involved Hunt Areas and Herd Units for mule deer (the Baggs, Chain Lakes, and Steamboat Herd Units) and about 18 percent of the involved Hunt Areas and 16 percent of the involved Herd Units for elk (the Sierra Madre, Shamrock, Petition, and Steamboat Herd Units). These percentages roughly indicate the project area's contribution to hunting activity based on these game populations. Additionally, the project area contains only about 2 percent of the Baggs Hunt Area, which attracts by far the most hunters of all three big-game animals among the areas overlapping the project area.



Map 3.12-1. Recreation in the CD-C project area

No warranty is made by the BLM for use of the data for purposes not intended by the BLM.

The total number of active pronghorn hunters using the Hunt Areas that overlap the project area rose from 1,034 in 2002 to 1,955 in 2006 (up 89 percent). Following a modest drop in 2007, pronghorn hunters declined dramatically in 2008 to 620, then rose to 694 in 2009. Deer hunters in the relevant Hunt Areas rose to 4,918 in 2007—up 15 percent from 2002—then dropped slightly in 2008 (4,098) and 2009 (4,646). Elk hunters rose to 3,767 in 2007—up 7 percent from 2006 but down 6 percent from 2002—then declined again to 3,057 in 2009—down 8 percent from 2007. **Table 3.12-2** presents the total active hunters for each species from 2002 to 2009.

Table 3.12-2. Number of active hunters by species in WGFD Hunt Areas that include the CD-C project area, 2002–2009

Game Species	**Hunt Areas Involved** (% of Hunt Area overlapping the project area)	2002	2003	2004	2005	2006	2007	2008	2009
Antelope	53 Baggs (2%) 55 Red Rim (28%) 57 S. Wamsutter (38%) 60 Table Rock (33%) 61 Chain Lakes (31%)	1,034	1,113	1,221	1,499	1,955	1,697	620	694
Deer	82 Baggs (2%) 84 Atlantic Rim (19%) 98 Chain Lakes (31%) 100 S. Wamsutter (38%) 131 Steamboat (13%)	4,280	4,487	4,048	4,070	4,834	4,918	4,098	4,646
Elk	21 Baggs (2%) 100 Steamboat (14%) 108 S. Rawlins (19%) 118 Shamrock Hills (31%) 124 Powder Rim (23%)	4,027	3,928	3,278	3,356	3,505	3,767	3,105	3,057

Source: Wyoming Game and Fish. Harvest Reports (annual). Analysis by Lloyd Levy Consulting LLC.

3.12.3 Recreation Trends

Apart from long-term trends in popularity, the main factor determining the number of hunters using a particular Hunt Area is WGFD's allocation of hunting licenses in response to demand and to game-management policies that balance the demand for hunting with the supply of game. BLM personnel have observed that recreational use in the RFO area in general appears to be steady or in a slight upward trend. If favorable conditions for wildlife were sustained in the future, then hunting throughout the RFO would likely continue near current levels. A similar trend may be expected in the project area.

OHV use in the project area that occurs in connection with hunting is limited to existing roads and two-tracks by the OHV designations published in the Rawlins RMP, although travel off-road up to 300 yards is permitted to retrieve a downed game animal or to access a campsite. Despite limitations, the proliferation of authorized and unauthorized OHV routes is expanding rapidly, potentially detracting from the recreational setting.

According to a survey in the Carbon County Land Use Plan, fishing, hunting, overnight camping, and nature appreciation are the four most important outdoor recreational activities to Carbon County residents. The plan notes that important outdoor recreational activities occur at facilities or on lands that are developed or managed by other agencies, so the plan encourages coordination to allow substantive input by the county into agency planning (Carbon County Board of Commissioners and Carbon County Planning Commission 1998). The land use plan contains no specific recreation plans for land within the project area.

Recreation is mentioned in the Sweetwater County Comprehensive Plan. The plan states that Sweetwater County goals and objectives relating to public lands and resources include a goal of promoting [public land management] agency awareness of County issues and interests: “These include, but are not limited to, natural resource exploration and development, multiple-use land and resource management practices, agriculture/ranching and recreation, and adequate public access to and across public lands” (Sweetwater County 2002).

3.13 LANDS WITH WILDERNESS CHARACTERISTICS

Lands with wilderness characteristics (LWCs) are blocks of public land possessing sufficient size, naturalness, and outstanding opportunities for either solitude or primitive and unconfined recreation, as defined in BLM Manual Section 6310 (BLM 2012f), Conducting Wilderness Characteristics Inventory on BLM Lands and Section 6320 (BLM 2012g), Considering Lands with Wilderness Characteristics in the BLM Land Use Planning Process.

A roadless area of more than 5,000 acres of contiguous BLM land is generally the minimum for consideration as an LWC; smaller roadless areas of contiguous BLM land may be considered when they are adjacent to an area already formally determined to have wilderness character or potential. These BLM manual sections define current policy on LWCs, directing BLM to:

1. Continue to conduct and maintain inventories regarding the presence or absence of wilderness characteristics; and
2. Consider identified lands with wilderness characteristics in land use plans and when analyzing projects under the National Environmental Policy Act (NEPA).

The policies stated in BLM Manual Sections 6310 and 6320 do not encompass wilderness areas already designated by Congress or formally identified Wilderness Study Areas (WSAs) which are pending before Congress and are managed as wilderness until a decision is made. Within the RFO, there are five WSAs, one of which—the Adobe Town WSA—is near the southwest boundary of the CD-C project area but does not overlay the project area. There are no designated wilderness areas in the RFO.

Specifically to comply with BLM Manual Section 6320, the RFO is tiering this analysis of the Proposed Action and alternatives to the approved Rawlins RMP issued in 2008 (BLM 2008a and b). During the land use planning process leading to the approved RMP, the RFO reviewed several citizens’ proposals for new WSAs. The RFO responded to these proposals by conducting inventories to determine whether the affected lands possess the wilderness characteristics of size, naturalness, or outstanding opportunities for primitive, unconfined recreation or solitude, and found two areas located adjacent to existing WSAs that possess one or more of these characteristics. However, neither of the two areas—Adobe Town Fringe and West Ferris Mountains—lies within the CD-C project area (see Rawlins RMP Draft EIS Map 2-45, Areas with Wilderness Characteristics, viewable online at <http://www.blm.gov/pgdata/etc/medialib/blm/wy/-programs/planning/rmps/rawlins/deis/maps.Par.89221.File.dat/48_Map2-45.pdf>).

Although ineligible for designation by BLM as WSAs, the Adobe Town Fringe and West Ferris Mountains areas with wilderness characteristics were considered for special, protective management under the RFO’s land use planning authority and were evaluated to determine whether they were manageable as wilderness. The majority of the areas under consideration are leased for oil and gas development, in which case the RFO would not have the means to prevent impairment of any wilderness character that may be present. Therefore, “the BLM elected to manage lands with wilderness character for multiple use and not for protection of wilderness character” (Rawlins RMP ROD, p. 1-3).

The RFO continues to update the inventory of public lands for wilderness characteristics. All new information regarding LWCs would be considered by the RFO in the future along with other resource information in developing and revising land use plans and when making subsequent project-level decisions.

3.14 CULTURAL AND HISTORICAL RESOURCES

3.14.1 Cultural Chronology of the Area

Archaeological investigations in the Great Divide Basin and the Washakie Basin indicate that the area has been inhabited by people for at least 12,000 years from Paleoindian occupation to the present. The accepted cultural chronology of the Great Divide and Washakie basins is based on a model for the Wyoming Basin by Metcalf (1987) and revised by Thompson and Pastor (1995). The prehistoric chronology of the Wyoming Basin, which includes the Great Divide and the Washakie basins, is documented in **Table 3.14-1**.

Table 3.14-1. Prehistoric chronology of the Wyoming Basin

Period	Phase	Age (B.P.)
Paleoindian	--	12,000–8500
Early Archaic	Great Divide	8500–6500
Early Archaic	Opal	6500–4300
Late Archaic	Pine Spring	4300–2800
Late Archaic	Deadman Wash	2800–2000/1800
Late Prehistoric	Uinta	2000/1800–650
Late Prehistoric	Firehole	650–250

B.P. = before present
Source: Metcalf (1987), as modified by Thompson and Pastor (1995)

Paleoindian Period

The Paleoindian period is the oldest period for which there is archaeological evidence. It began ca. 12,000 years B.P. and ended around 8500 B.P. This is the transitional period from the Wisconsin ice advance during the terminal Pleistocene to the warmer and drier climatic conditions of the Holocene. A savannah-like environment with higher precipitation than occurs today was prevalent in southwestern Wyoming. Understanding paleo-environmental conditions operating at the end of the Pleistocene and into the Holocene provides insights into the articulation between human populations and the environment (Thompson and Pastor 1995). Paleoindian sites are rare in southwestern Wyoming. Fifty-one sites have been documented to contain Paleoindian cultural material in the project area. One site includes a feature (a hearth) that dates to the Late Paleoindian period at 8840 ± 90 B.P. No cultural material was found with the hearth.

Isolated surface finds of Paleoindian projectile points are not uncommon and suggest that site preservation may be a major factor affecting the number of known sites. Paleoindian lithic technology is distinctive with projectile points serving as chronological/cultural indicators within the period. Paleoindian tool assemblages include lanceolate points, gravers, and end-scrapers (Thompson and Pastor 1995). Radiocarbon analysis of a mammoth tusk at one site dates the site to 11,000 B.P.

Archaic Period

Settlement and subsistence practices in southern Wyoming remained largely unchanged from the end of the Paleoindian period through the Archaic and continued until at least the introduction of the horse or even until historic contact. Reduced precipitation and warmer temperatures occurred ca. 8500 B.P. The environmental change at the end of the Paleoindian period led to a pattern of broad-spectrum resource exploitation, which is reflected in the subsistence and settlement practices of the Archaic period. The resource exploitation became more diverse during the Archaic period. Large side- and corner-notched dart points and housepits are found during the Archaic period, and the presence of groundstone implements suggests a greater use of plant resources during this period. Faunal assemblages from Archaic components document increased use of small animals (Thompson and Pastor 1995).

Late Prehistoric Period

The Late Prehistoric period (2000-650 B.P.) is subdivided into the Uinta and the Firehole phases. Large-scale seed processing and an increase in the number of features including roasting pits is noted in the Late Prehistoric period, as is the presence of pottery and the introduction of bow-and-arrow technology. A characteristic of the Uinta phase is clusters of semi-subterranean structures dating to ca. 1500 B.P. At least two different types of structures have been identified: a more substantial cold-weather habitation and a less substantial, warm-weather structure serving more as a windbreak. The Firehole phase is distinguished from the preceding Uinta phase by a dramatic decline in radiocarbon dates, possibly related to a decline in population density.

Proto-Historic Period

The Proto-Historic period begins sometime after 300 years B.P. with the first European trade goods to reach the area, and ends with the development of the Rocky Mountain fur trade 150 years ago. The Wyoming Basin was the heart of Shoshone territory during this period, with occasional forays into the area by other groups such as the Crow and Ute (Smith 1974). The most profound influence on native cultures during this time was the introduction of the horse, enabling Native Americans to expand their range. All forms of rock art denoting horses, metal implements, and other Euro-American goods are associated with the Proto-Historic period. Metal projectile points have been recovered from both surface and subsurface contexts in southwest Wyoming.

Historic Period

Historic use of the area is limited. Steep canyons, inadequate water supply, badlands, and escarpments make the area inhospitable for settlement with only limited ranching activities present. Historic site types include linear properties such as trails, railroads, and highways and associated sites such as stage stations, rail stations, and sidings. Other historic site types include cabins, historic inscriptions, mines, cemeteries, historic cairns, ranches, corrals, stock-herding sites, post offices, small towns, debris and trash dumps, monuments, and bridges. No homesteads have been documented in the project area. The Homestead Act of 1862 gave 160 acres to anyone who could pay a $10 registration fee and pledge to live on the property and cultivate the land. The Grazing Homestead Act of 1916 allowed grazing homesteads to file for 640 acres of land. The Act was intended to help cattlemen. The federal government retained the mineral rights to the land. In 1934, the Taylor Grazing Act and associated Executive Order 6910 ordered lands withdrawn from further homesteading claims. These laws ensured the federal government would be the largest single landowner in Wyoming (Gardner and Johnson 1989). Several ranches or ranch-associated activities have been documented in the project area. Fur trapping and trading was not an important occurrence in the study area due to the lack of perennial streams.

Linear historic sites are found within the study area. The Overland Trail crosses the mid-portion of the study area trending east to west. The Cherokee Trail transects the southern portion of the study area, trending east to west. The Rawlins–Baggs Road transects the southeastern portion of the study area, trending generally north to south. The road is located south of I-80 and east of WY 789. The Lincoln Highway and the original UPRR grade transect the project area trending east-west, generally paralleling south of the I-80 corridor.

Table 3.14-2. Historic chronology of the Great Divide Basin and the Washakie Basin

Phase	Age A.D.
Proto-Historic	1720 – 1800
Early Historic	1800 – 1842
Pre-Territorial	1842 – 1868
Territorial	1868 – 1890
Expansion	1890 – 1920
Depression	1920 – 1939
Modern	1939 – Present

Source: Massey 1989

3.14.2 Summary of Extant Cultural Resources

The project area encompasses approximately 1,680 sections of land for a total area of 1.1 million acres. The State of Wyoming Cultural Records Office in Laramie provided information on the previous work conducted and sites recorded in the project area. Records at Western Archaeological Services (WAS) were also consulted. There have been 20,473 cultural resource projects conducted and 4,860 sites recorded in the project area (prior to 2007). The inventoried area is comprised of 116,322 Block acres. The site density is 0.04 sites per acre. Many of the projects have been linear Class III cultural resource inventories for roads, pipelines, powerlines, and seismic projects. Block surveys include wells, compressor stations, and general block inventories. Other project types in the project area include Class I data reviews; Class II sampling surveys, monitors, and open-trench inspections; reclamation; range improvements; test excavations; data-recovery excavations; examination of ethnographic records; and historic record research. The total amount of open-trench inspections and monitors conducted in the project area has not been consistently recorded through the years. However, open-trench inspections on 36 projects and blading monitors on 35 projects within the project area have resulted in discoveries.

In southwest Wyoming, sand deposits (sand dunes, shadows, and sand sheets), alluvial deposits along major drainages, and colluvial deposits along the lower slopes of ridges are recognized as areas of higher archaeological sensitivity. Cultural resources are also likely to be found around internally drained playa lakes.

3.14.3 Site Types

Of the total of 4,860 sites recorded prior to 2007, 2,350 were located in Sweetwater County and 2,510 in Carbon County. Site types included: prehistoric sites (4,266), historic sites (281), and prehistoric/ historic sites (313). The total percentage for site types is: prehistoric sites (88 percent), historic sites (6 percent), and sites with prehistoric and historic components (6 percent). Of the recorded cultural resources, 0.04 percent have been listed on the National Register (2 sites; 1 has been destroyed), 23 percent (1,127) are recommended eligible for nomination to the National Register of Historic Places (NRHP), 50 percent (3,443) are recommended not eligible for nomination to the NRHP, 25 percent (1,201) remain unevaluated, and 2 percent (87) have been destroyed. Cultural resources documented in the project area include prehistoric open camps, prehistoric lithic debris scatters, historic sites, and prehistoric/historic sites. The types of sites that have been previously identified or predicted to be in the project area are discussed below.

3.14.3.1 Prehistoric Sites

Prehistoric site types identified in the project area include sites dating to all time periods, burials, housepits, rock art, hunting blinds, stone circles, rock alignments, rock shelters, cairns, pottery sites, prehistoric camps, milling/vegetable-processing sites, butchering/bone-bed sites, lithic scatters, quarries, and primary and secondary procurement sites. Many of these sites have undergone data recovery and/or test excavations.

Prehistoric camps contain evidence of a broad range of activities including subsistence-related activities. Cultural remains include formal features such as fire hearths, stone rings, cairns, rock art, lithic debris, chipped stone tools, quarries, evidence of milling/vegetable-processing activities including ground stone, and pottery. Single as well as long-term occupation are represented.

Lithic scatters consist of sites containing lithic debris such as debitage or stone tools. No features or feature remnants are found at the sites. The sites are interpreted as representing short-term activities.

Quarries are sites where lithic raw material was obtained and initially processed. Primary and secondary lithic procurement areas are geologic locations where chert and quartzite cobbles have been redeposited and later used by prehistoric inhabitants for tool manufacture. Archaeological landscapes are secondary lithic procurement sites identified within the project area. Landscapes are by definition not eligible to the National Register.

Human burials, rock art (both pictographs and petroglyphs), rock alignment sites, and rock shelters have been identified as sensitive or sacred to Native Americans. Few such sites have been located in all of southwestern Wyoming. Numerous stone circle and/or cairn sites have been identified in the project area. Prehistoric cairns are usually found along ridges overlooking seasonal drainages. Three rock shelters have been documented in the project area. One site in the study area contains prehistoric and historic rock art (Romanowski 1998), where two separate panels were identified. The southeast-facing panel contains a prehistoric zoomorphic figure near the top, similar to a horse or buffalo. Also noted were vertical scratches representing claw marks. The same panel contains a historic figure near the base. The second panel faces east and contains historic and modern petroglyphs.

Housepits are found throughout the study area, and radiocarbon analysis dated two internal features to 5900 B.P.

Pottery/ceramics have been documented in the project area as well as numerous pottery sites in southwestern Wyoming and northwestern Colorado. Small sherds from unknown vessel types were recovered from most of the sites, and one nearly complete corrugated pot was collected.

Prehistoric/historic site types (313) include prehistoric camp/historic debris scatters and prehistoric lithic scatters/historic debris scatters. These multi-occupation sites exhibit mixed surface components. Generally the historic components of these mixed sites are associated with transportation or sheep-herding activities.

Numerous sites have recently been excavated in the study area, and a data synthesis was compiled for the Rawlins RMP, greatly increasing the knowledge of hunter/gatherer subsistence strategies in the area. One site excavated as a result of the CIG Uinta Basin Lateral pipeline dates between 9300–1730 B.P. (Pool 2000). Five components have been identified at the Salamander site ranging from the Early Archaic period through the Late Prehistoric period (Fleming 2004). Other excavated sites in the project area have dated to the Late Archaic period and the Late Prehistoric period.

3.14.3.2 Historic Sites

A total of 281 historic sites have been documented in the project area. Site types include historic trails, stage roads, stage stations, ranches, cairns, and debris. Eligible historic linear sites that cross portions of the project area include the Overland Trail, the Cherokee Trail, the Rawlins–Baggs Road, the Lincoln Highway, and the UPRR. The Overland Trail crosses the south-central portion of the project area, the Cherokee Trail crosses the southern portion, and the Rawlins–Baggs Road transects the southeastern portion of the project area. The Lincoln Highway and the UPRR (original grade) trend east-west through the central portion of the project area and are located within an area known as the “Southern Corridor.” As part of planning for the project area, the Lincoln Highway and original grade of the UPRR were identified and evaluated. BLM has accepted the evaluation with SHPO concurrence.

Several sites are associated with the UPRR including sidings, rail camps, bridges, a culvert, and variations on the original grade. Five railroad sidings have been documented. Six railroad stations have been reported. Four bridges have been documented along the UPRR mainline. Other sites associated with the railroad include foundations, camp debris, a shed, and a dugout.

Towns and post offices played a part in the settlement of the project area. Towns were located along the UPRR and the Lincoln Highway. A post office, ranch, and stage stop were located at Dad, along the Rawlins–Baggs Road. Recorded communities along the tracks or highway include Tipton, Red Desert, Wamsutter, and Creston Junction. A "truss bridge" crossing Muddy Creek is considered eligible for nomination to the National Register.

The Cherokee Trail was used in the 1850s by members of the Cherokee Tribe moving from the Oklahoma Reservation to the California gold fields. A southern variant of the Cherokee Trail trends southwest, crossing Savory Creek, and staying south of Ketchum and Five Buttes. The trail crosses the South Fork of Cherokee Creek and then Smiley Draw, remaining south of Cherokee Creek. The road continues west, with Wild Horse Butte to the south, descending to the Muddy Creek drainage and continuing west through Blue Gap Draw. The Cherokee Trail through the project area was identified and evaluated as part of this project (Johnson 2006). As with any of the westward migratory trails of the mid-1800s, variants have been documented. Reasons for variations in routes include inaccessibility at certain times of year or members of the group may have traveled the route previously and found an easier or more direct avenue to water.

The Cherokee Trail has received a great deal of attention by writers and even the film industry. LeRoy Hafen, in his work *The Overland Mail,* contends that the pioneering efforts of the Cherokee Indians led to the eventual development of the Overland Trail. The net result of the combined effort of novelists, historians, and the media has been to create a highly romanticized trail that is still not well understood in terms of the people who used it and the location of the actual route taken by Cherokees traveling west from Oklahoma to California in 1850 (Gardner 1999).

Excerpts from a Cherokee Trail diarist found in *Cherokee Trail Diaries* (Fletcher *et al.* 1999) document stops along the southern variant of the Cherokee Trail. Mitchell (1850):

> "June 30 Sunday . . . frosty and plenty of ice   We took an object west [possibly Five Buttes] at a great distance west to travel to and had great trouble in getting to it   Too many bluffs & bad branches in the way   In the evening we got out of the mountains & got to a bad Swamp creek runing south [This is Muddy Creek north of Baggs, WY] Supposed to be a for of elk head [Little Snake] 7 of our men were dissatisfied with the corse we were travling & left us taking a more South corse"

The Overland Trail is recommended as eligible for inclusion on the NRHP. The Overland Trail goes through the project area, traversing the checkerboard land pattern, and has been previously evaluated with BLM and SHPO concurrence (Johnson *et al.* 2005). This evaluation included the associated stage stations. Duck Lake Stage Station, Coal Gulch Stage Station, and the Washakie Stage Station were stops along the Overland Trail. Gardner *et al.* (1993) states: "Construction of stage stations at Sulphur Springs, Washakie, and Duck Lake more than likely took place in 1862." This time frame coincides with Ben Holladay beginning his Overland Stage venture to connect Denver, Colorado, with Salt Lake City, Utah. "Home" stations offered travelers more amenities than "swing" stations where a change of horses occurred and travelers' meals were offered. Robert Foote, giving testimony to Senator Cameron during a request for reimbursement for destruction caused by Native Americans, stated that "Stations from Sulphur Springs west to Fort Bridger were built from stone." (Gardner *et al.* 1993) Along with the construction of the stage stations was the stringing of the telegraph wires. Freighters as well as emigrants used these routes.

The Rawlins-to-Baggs Stage Road is an eligible freight and stage road. Mail, goods, and passengers followed the road on freight wagons and the Overland Stage. The road is first documented in 1881 and there were subsequent stage stations built along the route. Only the southern tip of the project area overlaps the Rawlins-to-Baggs Stage Road. The entire segment of the stage road through the project area has been previously determined as not contributing to the overall eligibility of the road (Rosenberg 2006).

Seven historic rock-art inscriptions have been documented in the project area. The Overland Rock contains inscriptions associated with the Overland Trail and is listed on the National Register. Three sites are documented to contain historic rock inscriptions associated with sheep ranching. Nine historic ranches are documented within the project area and several additional buildings, foundations, corrals, and fences are ranch-associated. The ranches are generally associated with raising sheep. In Wyoming, large-scale sheep ranching did not appear until the latter decades of the 1800s; by 1920, however, it was one of the pillars of the state's economic base. Ranching families promoted economic wealth with hard work and by taking chances, such as expanding across the desert of southwest Wyoming. Ranching/stock-herding sites in the area are generally sheepherder camps exhibiting hole-in-top cans and purple glass. Refuse left behind from tending herds is usually located on terrain with water as well as a good view to watch over the herds. One historic log cabin has been documented in the study area. Also reported at the cabin site are a tipi ring and two fire pits. A wild-horse trap is reported in the project area.

Historic cairns, often associated with sheep-herding, are located on ridges or high points, sometimes overlooking seasonal drainages.

Historic debris/trash sites are found distributed throughout the project area. These scatters usually include trash associated with emigration and ranching/herding activities—condensed-milk cans, food cans, baling wire, glass, and milled wood. The sites are usually found on ridge tops in areas with vegetative cover conducive for forage and bedding.

One historic mine has been reported in the project area. The Bugas Mine is a small subsurface coal mine where low-grade coal was extracted, probably between 1950 and 1964. Gardner and Johnson (1991) recorded its location on a northeast-facing slope overlooking Hansen Draw, approximately one-half mile south of the Union Pacific Railroad and 2.5 miles northeast of Wamsutter. It is accessed by a faint two-track road. The surface extent of the Bugas mine includes a 17-mile-long trench with a mine portal at the west end that is partially blocked with earth. At the east end of the trench is a broad, flat tailings pile of low-grade coal with some mica cut fragments mixed in. Some low-grade uranium ore was noted in the mica cut-bank of the trench. It is unknown if any reclamation work has been conducted at the mine since the initial recording in 1991. The site is recommended not eligible for nomination to the National Register of Historic Places.

One grave, the Divide Burial, has been documented in the project area. The grave of a male Caucasian was located during the construction of a telecommunication line. The grave was located on Union Pacific land. Analysis of the human remains and associated coffin and grave goods indicate the male was about 23 years of age and was probably a railroad worker. His remains were moved to the Rock Springs, Wyoming, cemetery.

3.14.4 Summary

Based on information derived from the data review, it is evident that prehistoric cultural resources are found along the major ephemeral drainages and along the lower benches of escarpments that dominate the terrain in the project area. Sensitive areas include drainages such as Muddy Creek, and other locales where water was or is present—natural springs, playa lakes, and the larger ephemeral washes that provide intermittent water sources. The numerous springs in the project area would be likely to contain cultural resources. Seasonal drainages flow into the project area from several escarpments such as Flat Top Mountain, North Flat Top Mountain, Baldy Butte, Pine Butte, Chain Lakes Rim, Ruby Knolls, Coal Butte, High Point, Sugarloaf, Horse Butte, Luman Butte, Horseshoe Bend, Siberia Ridge, Lost Creek Butte, Delaney Rim, Wells Bluffs, Wamsutter Rim, and Big Hill. Certain topographic settings have higher archaeological sensitivity: eolian deposits (sand dunes, shadows, and sheets), alluvial deposits along major drainages, and colluvial deposits along lower slopes of ridges.

Two areas within the study area are identified by the RFO as especially sensitive. The first consists of approximately 127 cairns along a ridge system in the southern portion of the study area, and the second consists of a dune complex that spans nine sections. A sensitivity model and treatment plan for the dune complex was compiled as part of the CD-C project.

The subsistence and settlement patterns in the project area reflect a hunter-gatherer lifeway. Information about the Paleoindian period is sparse and is not well understood. Research into the subsistence and settlement patterns used during the Archaic period indicates summer occupations in the mountains, winter occupations in the foothills, and spring and fall movements utilizing all available zones (Creasman and Thompson 1997). Subsistence patterns in the Archaic period and the Late Prehistoric period are similar in that they are based on seasonal movement throughout the basins and foothills in response to the availability of floral and faunal resources (Creasman and Thompson 1997). A broad diet is evident in extensive procurement and processing of small mammals by 450 B.P. (Shimkin 1947), or possibly earlier (Bettinger and Baumhoff 1982). Numic-speaking Shoshonean groups occupied the Wyoming Basin and continued to reside there until Euro-American expansion relegated them to reservations beginning in 1868.

Historic use of the project area was limited by terrain and lack of perennial water sources. Ranches, limited irrigation, grazing, and limited ranching activities are identified by the historic debris scatters and historic record. Sheep ranching was an important industry historically, and continues today. Historic trails and stage stations are located within the project area including the Overland Trail, the Cherokee Trail, the UPRR (original grade), the Lincoln Highway, the Rawlins-to-Baggs Road, the Wamsutter-to-Baggs Road, and the Red Wash Wagon Road. Stage stations are associated with the Overland Trail and the Rawlins-to-Baggs Road.